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ANEURYSMS IN THE JOHNS HOPKINS HOSPITAL

ALL CASES TREATED IN THE SURGICAL SERVICE FROM THE OPENING OF THE HOSPITAL TO JANUARY, 1922

MONT R. REID, M.D.

CINCINNATI

In 1921 Prof. René Leriche requested of Dr. W. S. Halsted some information as to the end-results of the ligation of large arteries at the Johns Hopkins Hospital. Leriche was particularly interested in the occurrence of intermittent claudication and other evidences of anemia following arterial ligations. I had already been working on the compilation of data relative to our experience with aneurysms. With the aid of Dr. Halsted's secretary, Miss Mabel Reese, and one of Max Bröedel's pupils, Mrs. Schwartz, charts of all of our cases were rapidly completed in duplicate form. Leriche, in his article on "Resultats éloignés des Ligatures et des Résections artérielles," [1] makes recognition of the copy which was sent to him, and has referred in his paper to some of our late results following the ligation and resection of arteries.

Compilation of the following data relative to aneurysms was undertaken with the idea that I could have on hand material for the study and investigation of numerous problems connected with vascular surgery. As yet, only one problem, that of abnormal arteriovenous communications, has been considered.[2] As the field of vascular surgery is rather limited and carries special interest for only a small number of surgeons, it has seemed wise for me to publish my statistics and to trust that those interested in vascular problems will find in them something of value. For the sake of the completeness of this statistical study, the arteriovenous cases made the subject of a special investigation elsewhere are reproduced in abstract form.

1. Leriche, René: Ass. franç. de chir. Proc.-verb. XXXI Cong. franç. de chir., 1922.

2. Reference should be made to Reid, M. R.: Abnormal Arteriovenous Communications, Acquired and Congenital; Report of a Series of Cases, Arch. Surg. **10**:601 (March) 1925.

H.H.W.

1. SIX CASES OF ANEURYSM TREATED BY LIGATION OF THE AORTA

CASE 1.—*History.*—Dec. 17, 1906; 36; man; colored; single; teamster. Aneurysm abdominal aorta, six months' duration. Syphilis for ten years; not treated.

Symptoms and Physical Signs.—Severe pain for one and one-half years prior to admission. This began after heavy lifting. Heart 13.5 cm. to the left; 4 cm. to the right. Aneurysm at the celiac axis. Swelling extended from the ensiform to navel.

First Operation.—December 18. Dr. W. S. Halsted. Partial ligation of the thoracic aorta with aluminum band (No. 29). The band was placed about 10 cm. above the diaphragm.

Second Operation.—Jan. 10, 1907. Dr. W. S. Halsted. Very marked partial occlusion of the abdominal aorta between its bifurcation and inferior mesenteric artery. Pulse was barely perceptible just below the band.

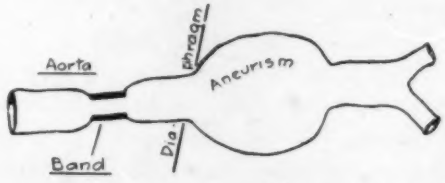

Fig. 1.—First operation in Case 1: partial occlusion of the aorta with a metallic band.

Fig. 2.—Second operation in Case 1: application of a second metallic band just below the inferior mesenteric artery.

Postoperative Course.—The first operation gave a little relief from pain and resulted in only a slight decrease in size of the aneurysm. The blood pressure in the legs was lower than in the arms for the first twenty-four hours; after that it was the same in both arms and legs. After the second operation the wound leaked clear, straw colored, uninfected fluid. The aneurysm did not improve but increased in size. Signs of a thoracic aneurysm appeared. There was severe pain. The blood pressure could never be measured in the legs after the second operation. The femoral pulse could be felt only occasionally.

Result.—Death, January 28.

Necropsy.—Rupture of aneurysm into posterior mediastinum and peritoneal cavity. Thoracic aneurysm; esophageal obstruction from pressure. Chronic adhesive peritonitis. Circulation in legs remained good. First band 7 cm. long, 2 cm. wide; second band 7 cm. long, 1 cm. wide.

CASE 2.—*History.*—April 9, 1908; 58; man; white; widower; laborer. Aneurysm left common iliac artery, six months' duration. No history of venereal infections.

Symptoms and Physical Signs.—Nausea and a sensation of fulness in the stomach. A lump in the abdomen for four months. A large mass to the left of and below the umbilicus. Right femoral pulse weaker than the left. Blood pressure in right leg 115, left 210. Sensation and function in legs not impaired. Heart measured 11.5 cm. to the left of midline.

Operation.—April 14. Dr. W. S. Halsted. Attempt to apply a metallic band to the abdominal aorta for aneurysm of left common iliac artery. Rupture of sclerotic aorta. Ligation of aorta with tapes after several tapes had cut through.

Postoperative Course.—The patient lived about twelve hours.

Necropsy.—Aneurysm of left common iliac artery; arteriosclerosis; cardiac dilatation and hypertrophy.

CASE 3.—*History.*—Feb. 28, 1909; 53; man; white; married; physician. Aneurysm abdominal aorta, from eight to twelve months' duration. No history of venereal infection.

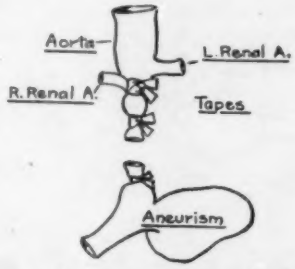

Fig. 3.—Forced ligation of the aorta in Case 2 after attempted banding had cut through the sclerotic vessel wall.

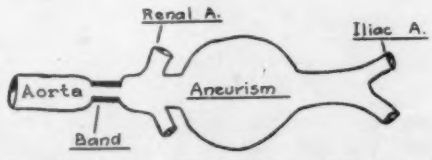

Fig. 4.—First operation in Case 3: partial occlusion of the abdominal aorta with a metallic band.

Symptoms and Physical Signs.—Pain in back for eighteen months. Heart normal. Pulsating mass just above the umbilicus. Blood pressure in the foot, 160; in the radial, 150. Aneurysm 6 cm. in diameter.

First Operation.—February 23. Dr. W. S. Halsted. Application of metal band to abdominal aorta for abdominal aneurysm. Metal No. 25 used.

Second Operation.—March 12. Dr. J. M. T. Finney. Wiring of abdominal aneurysm with 11 feet of wire; galvanic current.

Postoperative Course.—After the first operation there was a decrease in the size of the mass and in the pain until March 7, but after that there was a sudden change for the worse, with the onset of fever, increase in size, pulsation and pain. There was no disturbance in circulation in the legs. The second operation was followed by a rapid increase in the size of the aneurysm with gradual weakness, although the circulation in the legs remained good.

Result.—Death, April 14.

Necropsy.—Abscess about the band, which had not yet cut through. Considerable organization about the wire. Rapid growth of the aneurysm probably due to the infection.

CASE 4.—*History.*—April 18, 1917; 31; man; white; single; clerk. Aneurysm abdominal aorta, eighteen months' duration. No history of syphilis. Wassermann reaction negative; syphilitic aortitis.

Symptoms and Physical Signs.—Pain in small of back first; later in legs and abdomen. Heart normal. Pulsation in left back. Small mass below left costal margin. Blood pressure in right arm, 125/90; left arm, 177/90; right leg, 150/90; left leg, 130/93. Area of anesthesia around left hip.

Operation.—May 1. Dr. G. J. Heuer. Application of aluminum band about the thoracic aorta for abdominal aneurysm at the level of the celiac axis. Metal No. 33, 6 mm. wide was used. Constriction two-thirds. The pulse could readily be felt in the femoral and iliac arteries after the operation.

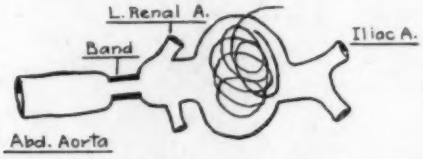

Fig. 5.—Second operation in Case 3: wiring of the aneurysm below the band.

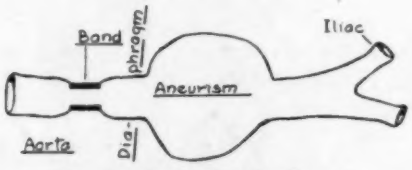

Fig. 6.—Operation in Case 4.

Postoperative Course.—There was slight relief for a couple of weeks. The aneurysm in the back did not change; it seemed to clot a little anteriorly. The patient died suddenly with spitting and coughing of blood. The left chest was filled with a serosanguineous fluid.

Result.—Death, June 9.

Necropsy.—The band had cut through and the aorta had connected with the lung into which a large false aneurysm formed, finally rupturing into a bronchus. There was a small clot in the aneurysm posteriorly. Syphilitic aortitis.

CASE 5.—*History.*—May, 3, 1920; 40; male; colored; single; stevedore. Aneurysm abdominal aorta, duration two years. Syphilis for eighteen years, with secondary eruption. Wassermann reaction negative.

Symptoms and Physical Signs.—Pain and weakness in the abdomen. Mass noted for seven months, coming on after severe vomiting spell. Aortic insufficiency. Large abdominal aneurysm at the celiac axis.

Operation.—May 18. Dr. M. R. Reid. Large abdominal aneurysm explored. Aorta above it freed, but no band or ligature applied. Pleural cavity opened from below diaphragm. Aneurysm fusiform.

Postoperative Course.—Aneurysm unchanged. Given numerous injections of arsphenamin.

Result.—There was no improvement after operation. Late result not known.

CASE 6.—*History.*—April 12, 1921; 36; man; colored; single; janitor. Aneurysm of the abdominal aorta, four months' duration. Syphilis for fifteen years; Wassermann reaction positive.

Symptoms and Physical Signs.—Large pulsating mass at the level of the umbilicus. Heart normal. Blood pressure in both legs, 140/100; in the arm, 116/80.

First Operation.—April 30. Dr. M. R. Reid. Incomplete occlusion of the abdominal aorta with cotton tape for abdominal aneurysm.

Second Operation.—August 3. Dr. M. R. Reid. Complete ligation of the abdominal aorta above the celiac axis.

Postoperative Course.—The circulation in the legs remained good after the first operation. There was improvement for a month or two, and then extension of aneurysm posteriorly, and pressure on the lumbar nerves. The pulse was noted in the legs within four hours after the first operation and gradually

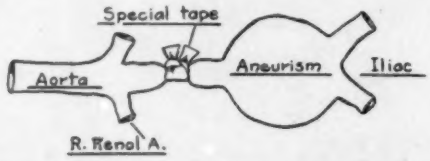

Fig. 7.—First operation in Case 6: almost complete occlusion of the aorta with wide tapes.

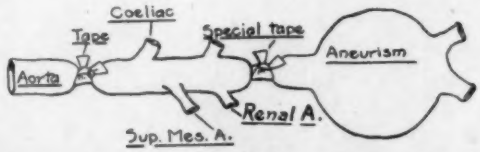

Fig. 8.—Second operation in Case 6 three months after the first: complete ligation of the aorta above the celiac artery.

became very good. After a week the pulse gradually grew weaker in the legs and was gone by May 28. After the second operation the circulation in the legs seemed as good as before, and there was no paralysis due to anemia. Death was due to rupture of the aneurysm into the thorax through the diaphragm.

Result.—Death, September 14.

Necropsy.—Aneurysm of the abdominal aorta, ligature below the renal arteries and ligature above the celiac axis; formation of second aneurysm. Rupture of second aneurysm into the pleural cavity. At necropsy both ligatures were found to have cut through but the hemorrhage had not occurred at either of these points.

Remarks.—There was no circulatory disturbance of the legs in the form of anemic contractions or lowered surface temperatures. The disappearance of the pulse in the legs after the first operation was due to a fall of systolic and a rise of diastolic pressure, the two coming together.

2. FIVE CASES OF ILIOFEMORAL ANEURYSM

CASE 7.—*History.*—Dec. 28, 1908; 44; man; white; married; watchman. Aneurysm left iliofemoral artery, two and one-quarter years' duration. Syphilis for twenty-two years.

Symptoms and Physical Signs.—Hit in the groin by a fall on a barrel three months before the pain and swelling appeared. The heart was normal. A mass 21 by 17.5 cm. was present. The left foot was cold and the pulse could not be felt in the dorsalis pedis artery. There was great edema, but no anesthesia. The center of the aneurysm was under Poupart's ligament.

Operation.—Jan. 11, 1909. Dr. W. S. Halsted. Occlusion of the common iliac artery with an aluminum band.

Postoperative Course.—Five hours after operation the left leg to the knee was warmer than the right; this was true for the next twenty-four hours. Then it was a degree or so lower for a day or two. After that, no record

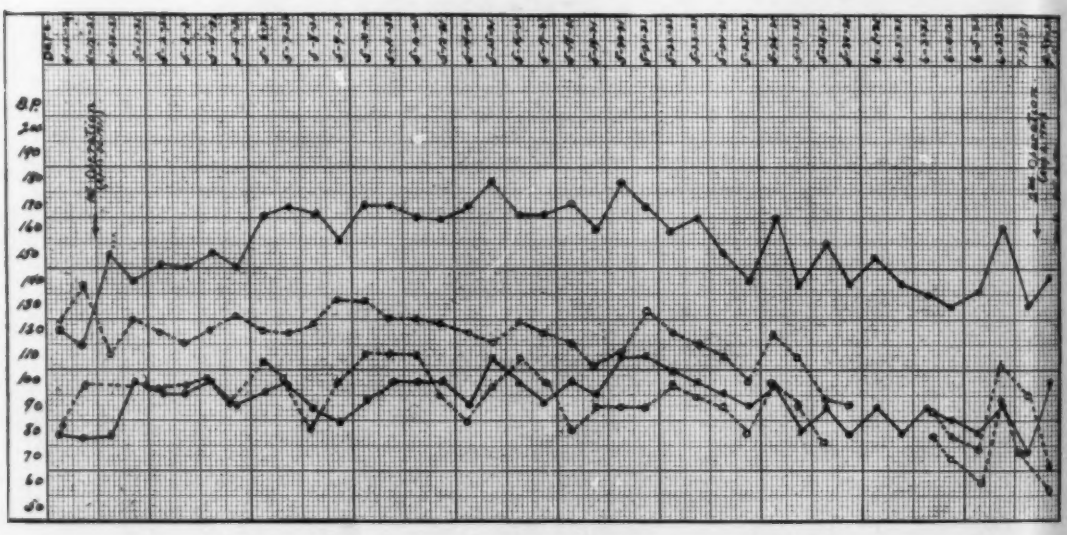

Fig. 9 (Case 6).—Effect of partial and complete occlusion of the human aorta on the blood pressures in the arm and leg: at the first operation the aorta was nearly occluded just below the renal arteries; at the second it was completely occluded just above the diaphragm. When the blood pressure in the leg could not be measured, as on May 30, June 1, 2 and 3, a femoral pulse could usually be detected; no gangrene resulted.

was made. The left foot remained cold and at no time became as warm as the right. There was never any worry as to the life of the leg. No gangrene. The pulse did not return below the aneurysm before discharge. There was only a small area of anesthesia in the leg.

On discharge the aneurysm was hard and nonpulsating. No antisyphilitic treatment was given.

Result.—The patient was well, June 4, 1917.

Jan. 19, 1910, one year postoperative, the patient writes: "The aneurysm has completely left me. I sometimes experience a little pain in my left leg

when walking fast, otherwise can complain of nothing." A photograph of the groin received a few weeks later shows no trace of the aneurysm, only a broad vertical scar.

April 4, 1912, three and one-quarter years postoperative, the patient writes: "My left leg is a great deal weaker than my right. I don't limp any. I can't walk very much, as I have pains in my left leg when I do any walking, and in case it gets very cold. . . . . All traces of the aneurysm have disappeared, and it never worries me the least bit."

Observation on June 4, 1917, showed the aneurysm gone. There was no swelling; a faint but countable pulse was present in the foot, although the femoral pulse was questionable. The liver was enlarged, and the patient suffered from a cough due possibly to thoracic aneurysm. There was a hernia of the wound. A note by Dr. Halsted states that death occurred from carcinoma of the rectum, but the date is not known.

Case 8.—*History.*—Jan. 13, 1911; 29; white; single; sailor. Aneurysm of the right iliofemoral artery of eight days' duration. Syphilis seven years; gonorrhea; Wassermann reaction negative.

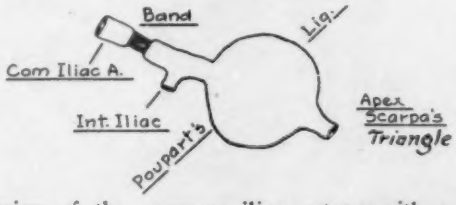

Fig. 10.—Occlusion of the common iliac artery with a metallic band in Case 7.

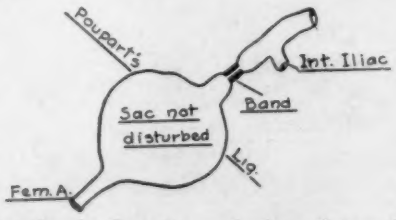

Fig. 11.—First operation in Case 8: marked partial occlusion of the external iliac artery.

Symptoms and Physical Signs.—Heart enlarged, 14.5 cm. to the left and 4 cm. to the right. Aortic insufficiency. Mass 16 by 10.5 cm. Blood pressure 140 in the left leg, 195 in the right. Pulse better in the right foot than in the left.

First Operation.—January 14. Dr. W. S. Halsted. Partial occlusion of the external iliac artery by an aluminum band. Band rolled until the pulse disappeared at the knee and foot, but was faintly felt in the femoral. Closure with silver wire.

Second Operation.—February 2. Dr. W. S. Halsted. Ligation of the femoral, profunda and circumflex arteries and femoral vein.

Postoperative Course.—Pulse noted in the foot seven hours after the first operation. "On the day after operation the surface temperature was much higher in the right leg." No sensory or motor disturbances. Pulse in the aneurysm lessened. Blood pressure in the right leg was 60/100. Aneurysm

began to increase upward before the second operation. On the fourth day after the second operation the surface temperature was the same in both legs. The pulse in the foot was not felt, but the circulation was good. No sensory or motor changes. Pulsation did not return in the foot. The aneurysm ceased to pulsate.

Result.—September 28, well.

A note by Heuer four days after the first operation: "For about the first four hours the surface temperature of the right leg was recorded as definitely lower than the left, varying from 2 to 8 degrees lower than on the normal side. Three hours before the pulse in the dorsalis pedis artery could be felt the surface temperature became equal and remained so for about twelve hours. Following this the temperature on the right side became higher than on the left, but the difference on the two sides was not great (from 1 to 2 degrees) nor did it definitely continue so for long."

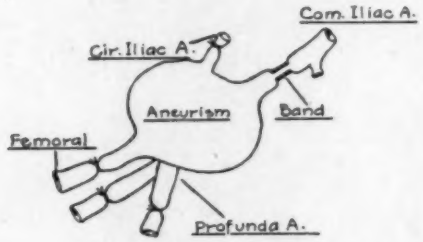

Fig. 12.—Second operation in Case 8 nineteen days after the first: ligation of the arteries distal to an iliofemoral aneurysm.

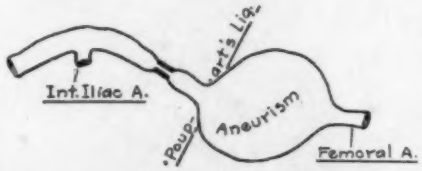

Fig. 13.—First operation in Case 9: partial occlusion of the left external iliac artery.

Case 9.—*History.*—April 10, 1913; 40; man; colored; married; farmer. Aneurysm of the left iliofemoral artery of eleven months' duration. No history of syphilis. Wassermann reaction positive.

Symptoms and Physical Signs.—No trauma. Steady growth. Marked edema of the leg developing in the last five months. Heart slightly enlarged; systolic bruit. Aneurysm 15.5 by 6 cm. Expansile pulsation. Left leg very black. No pulse in the foot. No sensory or motor paralyses. Leg elevated for a long time to reduce brawny edema.

First Operation.—May 21. Dr. W. S. Halsted. Application of a metallic band to the left external artery. A very faint pulse was felt beyond the band (no thrill). Pulsation in the aneurysm ceased. Silk closure.

Second Operation.—July 7. Dr. W. S. Halsted. Excision of left iliofemoral aneurysm. Closure of the wound with through and through silver wire. Cigaret drain.

Postoperative Course.—After the first operation a slight pulsation returned about the fourth day and this increased a little for a week. The edema subsided moderately. The foot was cold for eight or ten hours; after that it was as warm as the other. The sensation was unaffected. A very faint pulse was detected in the dorsalis pedis and posterior tibian arteries by Dandy on June 7. Great relief from pain.

The wound of the second operation healed by first intention. The foot and leg were colder for four days; then both legs were of the same temperature. No gangrene. Sensation and function perfectly restored. July 8, Dandy thought he felt a pulse in the foot; no one else felt it.

Result.—Well, Nov. 29, 1915. The leg was normal; patient works and rides sixteen miles on a bicycle without tiring. Color of leg normal.

Returned for observation, Jan. 5, 1917. Perfectly well. No pulse in the leg. Very slight swelling.

Figure 13 is according to Heuer's note. Dr. Halsted's note says that the femoral was tied below the profunda, but it does not mention tying the profunda artery after opening the sac.

CASE 10.—*History.*—April 29, 1913; 27; man; colored; married; musician. Aneurysms of right iliofemoral artery and thoracic aorta, duration nine months. Syphilis ten years, with secondary eruption; gonorrhea; Wassermann reaction positive.

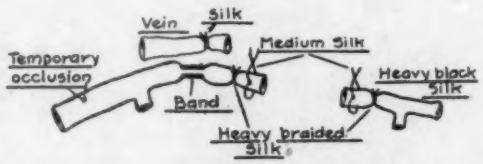

Fig. 14.—Second operation in Case 9: excision of the aneurysm and femoral vein forty-seven days after the first operation.

Symptoms and Physical Signs.—No injury. Heart normal. Very large pulsating iliofemoral aneurysm. Pulse in the foot. Aneurysm mainly femoral. Cough and bloody sputum suggested thoracic aneurysm.

Operation.—May 5. Dr. W. S. Halsted. Application of metallic band to external iliac artery for iliofemoral aneurysm. Only moderate occlusion, not sufficient to stop the pulse in the aneurysm.

Postoperative Course.—Patient died eight days after operation. Great respiratory distress (approaching suffocation) and pneumonia. Pulse returned in foot. No sensory or motor changes.

Result.—Death, May 13.

Necropsy.—A thoracic aneurysm about to rupture into the trachea, and pneumonia. With the history and physical findings recorded previous to operation it seems that this patient should not have been operated on. Syphilitic mesarteritis of pulmonary arteries and their fine branches; syphilitic arteritis; saccular aneurysm of arch of aorta, several of the descending aorta, one of the splenic artery and one of the right femoral artery.

CASE 11.—*History.*—Nov. 29, 1915; 43; man; white; married; clerk. Aneurysm of the right iliofemoral artery of eight weeks' duration. Syphilis twenty years, with treatment for six days. Wassermann reaction positive.

Symptoms and Physical Signs.—Onset of aneurysm after heavy lifting. Aneurysm 10.5 by 8 cm. Slight swelling. Severe pain in the right knee. Relief obtained by acute flexion of the thigh which cut off the pulse in the foot and decreased the pulsation and bruit. Surface temperature right leg 90; left leg 90.8. Blood pressure right leg 102/84; left leg 112/82; arm 112/82. Sensation and function normal. Heart slightly enlarged; no murmurs.

First Operation.—December 4. Dr. W. S. Halsted. Partial occlusion of the right external iliac artery, with an aluminum band, for an iliofemoral aneurysm. Collodion technic. After the constriction there was just a faint pulse and a very faint thrill. Silk closure.

Second Operation.—Feb. 14, 1916. Dr. W. S. Halsted. Antyllus' operation for right iliofemoral aneurysm. Collodion technic. No attempt to obliterate the sac. Lateral suture of rent in vein. Silk closure; no drain.

Postoperative Course.—Faint pulse in the posterior tibial artery detected eleven hours after operation. Circulation remained excellent. Pulsation of the aneurysm greatly reduced. Leg nine hours after operation was "warm." Severe

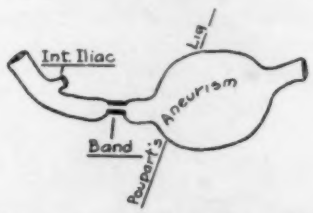

Fig. 15.—First operation in Case 11: partial occlusion of the external iliac artery.

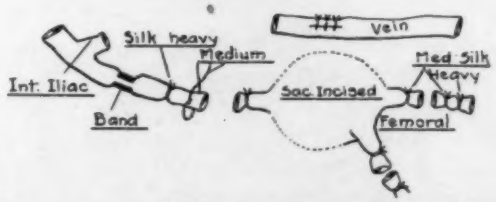

Fig. 16.—Second operation in Case 11 ten weeks after the first.

pain gradually relieved. No sensory or motor changes. Tumor gradually became smaller and partly clotted, being on Feb. 13, 6.5 by 7.5 cm., and pulsation greatly reduced. The posterior tibial pulse was very variable, at times distinct, at others almost imperceptible. Surface temperature from 2 to 3 degrees lower for one week; after that about one-half to 1 degree lower.

After the second operation the calf of the leg ached severely for eighteen hours. The leg was kept warm and frequently massaged for a day, on account of the venous stasis and coldness. No motor paralysis. Small area of anesthesia on the inner side of the big toe and knee. Healing by first intention except that some *sterile* serum had to be removed on two occasions. Severe reaction to arsphenamin (only one dose taken). Took mercury. Surface temperature lower to the touch for several days; then gradually the same as the other leg.

Result.—November 2, well except for pain in the leg and calf. Can walk only about 2 or 3 blocks, and then the "blood seems to quit." Aneurysm cured.

April 22, 1918, well. Tibial pulse easily counted. Patient perfectly well, except for a little pain and paresthesia in the knee. Aneurysm healed. No swelling of the leg. Referred for syphilitic treatment.

Sept. 10, 1922, well. Legs appear normal.

3. TEN CASES OF FEMORAL ANEURYSM

CASE 12.—*History.*—Feb. 27, 1896; 28; man; white; married; farmer. Aneurysm of the right femoral artery at the upper end of Hunter's canal, of fifteen years' duration. Causation a knife blade. No history of syphilis or gonorrhea.

Symptoms and Physical Signs.—Size 9 by 8 cm. Small pulse in the posterior tibial and dorsalis pedis arteries. Leg not swollen. Heart normal. Artery ligated six years before, following which there were three severe secondary hemorrhages. Boiling water injected.

Operation.—March 6. Dr. W. S. Halsted. Complete excision of aneurysm of the femoral artery at the apex of Scarpa's triangle and the beginning of Hunter's canal. Femoral artery and vein ligated above and below. Irrigation with mercuric chlorid 1 : 1,000. Wound packed with gauze on account of oozing. One hundred vessels tied.

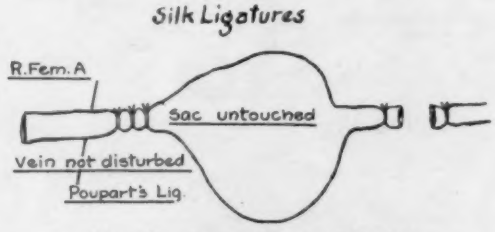

Fig. 17.—Operation in Case 13.

Postoperative Course.—Pack removed and the wound irrigated and closed on the day after operation. Wound suppurated and healed by granulation. Tub bath treatment. Circulation in the leg remained good.

Result.—Well, April 20.

May, 1, 1922, the patient replied that there was no impairment of function of the operated leg, but that since the operation the veins of the lower leg had become enlarged and he was obliged to wear an elastic stocking. He is very active, working on a farm.

CASE 13.—*History.*—Aug. 17, 1896; 62; man; colored; married; coachman. Aneurysm of the right femoral artery in Scarpa's triangle of six months' duration. No history of venereal disease.

Symptoms and Physical Signs.—Swelling of the size of the closed fist just below Poupart's ligament. Heart normal. No record of nerve involvement.

Operation.—August 21. Dr. J. M. T. Finney. Ligation of the common femoral above and below the aneurysm. Sac untouched. Irrigation with 1 : 1.000 mercuric chlorid. Closure with silver wire.

Postoperative Course.—Healing by first intention except a small opening in the lower end of the wound. Circulation rather questionable for eight hours. Then it became good and remained good. No gangrene.

Result.—Well, September 13. No further history.

CASE 14.—*History.*—Nov. 30, 1900; 36; man; colored; married; laborer. Aneurysm of the left femoral artery in Hunter's canal, of eight days' duration. Syphilis for five years, with secondary eruption. Gonorrheal infection fifteen years.

Symptoms and Physical Signs.—Pain for eight days. Tumor for three days. Numerous scars of old syphilis. Heart normal. Pulse in the foot retarded. Tumor 8 by 10 cm.

Operation.—December 19. Dr. W. S. Halsted. Ligation of the left femoral artery below the profunda artery. Closure with silver wire. Vein undisturbed.

Postoperative Course.—Pleurisy of the right side. January 15 (twenty-five days after operation), a slight pulse was noted for the first time in the dorsalis pedis artery. Aneurysm pulseless and hard. No note of treatment for syphilis.

Result.—No further history.

CASE 15.—*History.*—Feb. 6, 1906; 50; man; colored; widower; laborer. Aneurysm of the left femoral artery of from nine to fourteen months' duration. Syphilis for 20 years with secondary eruption. Gonorrheal infection six times. No record of any treatment.

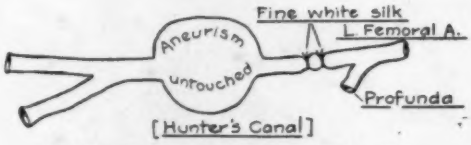

Fig. 18.—Operation in Case 14.

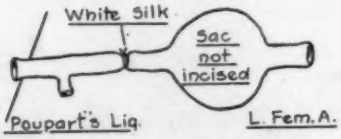

Fig. 19.—Operation in Case 15.

Symptoms and Physical Signs.—Heart normal. Onset with acute swelling of the leg below the knee. Pulsating tumor in the lower end of Hunter's canal, size about that of an orange. Posterior tibial pulse not felt; weaker than normal in the dorsalis pedis. The left leg was longer than the right.

Operation.—February 16. Dr. W. S. Halsted. Ligation of the left femoral artery at the apex of Scarpa's triangle for aneurysm of the femoral artery. Silver wire closure.

Postoperative Course.—The pulse in the foot disappeared after operation but returned on February 18 in the dorsalis pedis artery.

Result.—Well, March 31. No further history.

CASE 16.—*History.*—Sept. 13, 1912; 31; man; white; married; merchant. Aneurysm of the right popliteal artery due to a pistol shot, of four weeks' duration. No history of syphilis, but has had two gonorrheal infections.

Symptoms and Physical Signs.—Pistol shot wounds healed without infection. Pain and sudden swelling for the last ten days. Heart normal. Considerable swelling of the leg. Anesthesia on the anterior part of the lower leg. No pulse in the foot. False aneurysm with edema about it.

Operation.—September 23. Dr. J. M. T. Finney. Ligation of the popliteal artery proximal and distal to a false aneurysm. Antyllus' operation. Large blood clot evacuated. Closure with catgut.

Postoperative Course.—The circulation was never embarrassed. No comment was made on the sensation, surface temperature, etc. The function was perfect.

Result.—October 3, well. No further history.

I believe that this was an aneurysm of the femoral artery in Hunter's canal, and not of the popliteal.

CASE 17.—*History.*—May 12, 1915; 57; man; colored; married; laborer. Aneurysm of the left femoral artery in the lower part of Hunter's canal, of two weeks' duration. Gave a history of syphilis two years before, but the Wassermann reaction was negative.

Symptoms and Physical Signs.—Heart normal. False aneurysm; acute pain, rapid swelling, edema, etc. Leg swollen but circulation good. Nerves not affected.

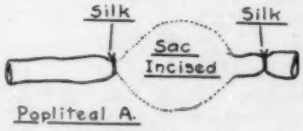

Fig. 20.—Operation in Case 16.

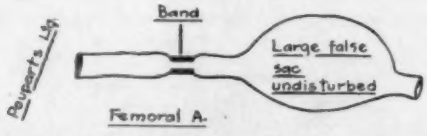

Fig. 21.—First operation in Case 17: application of partially occluding band above the aneurysm.

First Operation.—May 18. Dr. W. S. Halsted. Application of metallic band to femoral artery for femoral aneurysm, left. Closure with silk. "Only the faintest pulse, no thrill, palpable below the band." No pulse in the aneurysm.

Second Operation.—August 21. Dr. R. H. Follis. Incision of infected aneurysm. Ligation of entering and exit artery. Drainage.

Postoperative Course.—After the first operation there was no circulatory disturbance in the foot, nor any nerve disturbance. The swelling subsided. Infection of the wound presented and opened nearly two months after operation. The aneurysm did not clot after the first operation. There were no secondary hemorrhage, circulatory or nerve disturbances. A small sinus persisted at the time of discharge. The pulse did not return distally after the first or second operations.

Result.—October 2, well.

The patient returned March 23, 1916, for a discharging sinus. Some black silk stitches were removed. The pulse had not returned in the foot. The nerves were all right. There was still some swelling of the leg.

July 18, 1916, death; cause of death not known.

The failure of the blood to clot was probably due to infection, perhaps to blood coming under the band.

CASE 18.—*History.*—May 2, 1916; 33; woman; colored; divorced; clerk. Aneurysm of the left femoral artery. No history of syphilis; Wassermann reaction strongly positive. The aneurysm was of twenty days' duration.

Symptoms and Physical Signs.—The patient had scars of discharging gummatous lesions (patella). There was a ruptured aneurysm in the lower part of Hunter's canal. Swelling 10.5 by 15 cm. No pulse felt below the aneurysm. The surface temperature was the same in both legs. Surface anesthesia of the inner side of the calf was present. There was some edema. The heart was not enlarged.

Operation.—May 20. Dr. M. R. Reid. Collodion technic. Antyllus' operation. No drain. Sac incised and clot extruded. No attempt to obliterate the sac. Silk sutures and ligatures used.

Postoperative Course.—The pulse in the dorsalis pedis artery was detectable at 3 p. m. and could be counted at 10 p. m. the day of operation. The edema disappeared. The patient was given antisyphilitic treatment.

Result.—Well, June 5.

Well in the fall of 1921. The pulse could still be felt in the foot. No complaint of weakness.

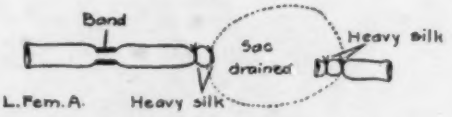

Fig. 22.—Second operation in Case 17 three months after the first: incision and drainage of infected aneurysm; ligation of the proximal and distal arteries.

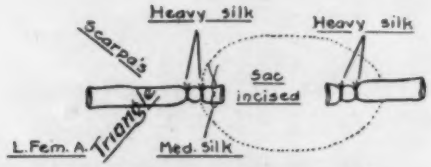

Fig. 23.—Operation in Case 18.

In a letter of April 24, 1922, the patient noted a loss of power in the leg at times.

CASE 19.—*History.*—March 24, 1917; 38; man; white; single; machinist. Aneurysm of the right femoral artery of eight weeks' duration. Syphilis for eight years; gonorrhea twice; Wassermann reaction strongly positive.

Symptoms and Physical Signs.—The onset began with pain and tremor of the leg. The heart was normal. An area of anesthesia was present on the inner side of the knee and thigh. The blood pressure in the right arm was 118/80; in the left leg, 180/115; right leg, 110/90. There was a "numb feeling" and pain in the knee. No swelling of the leg. A swelling 11 by 9.5 cm. presented just below Poupart's ligament. A faint pulse was detected in the posterior tibial, but not in the dorsalis pedis artery; easily felt in the other leg. "No definite difference in the surface temperature." No pulse could be felt in the popliteal artery.

Operation.—April 5. Dr. M. R. Reid. Application of occluding metallic bands above and below the aneurysm. Closure with silk. Two incisions, one above and one below the aneurysm.

Postoperative Course.—For two days the surface temperature of the right leg was lowered; the color and circulation, however, were good. After two days no difference was noted in the surface temperatures. The area of anesthesia did not change. The pulse in the foot was noted two days after operation; though it was very weak, it remained countable. The aneurysm clotted. The wounds healed by first intention except for a skin slough of the lower one about the size of a dime. Many arsphenamin treatments were given. The blood pressure in this leg was not measurable after operation.

Result.—Well, May 24.

Observation, April 20, 1918, showed no trace of the aneurysm. The function was perfect except for an occasional pain in the knee joint. The pulse could be felt in the foot. The area of anesthesia was nearly gone. No further history.

CASE 20.—*History.*—April 19, 1919; 53; man; white; married; farmer. Aneurysm of the left femoral artery in Hunter's canal, of nine months' duration and of traumatic origin (pistol shot). No history of syphilis or gonorrhea.

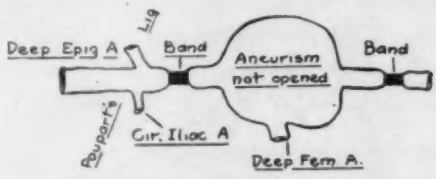

Fig. 24.—Operation in Case 19.

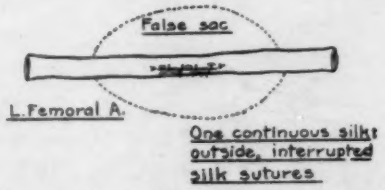

Fig. 25.—Suture of a rent in the femoral artery which had produced a large false aneurysm in Case 20; restoration of the lumen of the vessel.

Symptoms and Physical Signs.—Very large false aneurysm. Pulse in the foot very variable. Anesthesia on the inner side of the calf. Enormous edema of leg. Heart normal.

Operation.—April 23. Dr. M. R. Reid. Enucleation of blood clot from a false aneurysm and lateral suture of a rent in the vessel.

Postoperative Course.—The pulse was palpable distally after the suture, and was better in the posterior tibial than before the operation. There was no impairment of the circulation. The temperature of the leg was not commented on. The area of anesthesia was not changed.

Result.—Well, May 24.

CASE 21.—*History.*—March 24, 1921; 38; man; colored; laborer. Aneurysm of the left femoral artery of three and one-half months' duration. Gonorrhea twice; syphilis for fifteen years; Wassermann reaction negative.

Symptoms and Physical Signs.—The patient was hit in the groin by a piece of wood one month before the swelling was noted. There was a rapid increase of the swelling in the last week due to rupture of the aneurysm into the tissues.

The surface temperatures of the legs were the same. "The calf was very tender." A zone of anesthesia in the front of the lower leg. The heart was normal. Twitchings were seen in the calf muscles.

Operation.—March 28. Dr. M. R. Reid. Antyllus' operation. Closure with silk without drainage. A good pulse was noted in the distal end of the divided artery at the time of operation.

Postoperative Course.—The pulse was well felt in the foot four hours after operation: on the day after operation it was better than it was before operation. The surface temperature of the left leg was definitely increased for two days. There was no change in the area of anesthesia. The edema subsided. There was no impairment of the circulation. There were some twitchings of the calf for two days.

Result.—Well, May 4.

June 6, 1922, on examination there was no trace of the aneurysm. The patient was a hod carrier and worked daily without any trouble. A good pulse could be felt in the arteries of both feet. No history nor evidence of intermittent claudication.

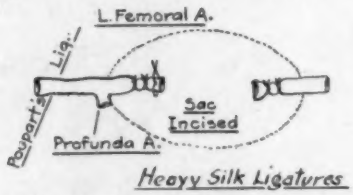

Fig. 26.—Operation in Case 21.

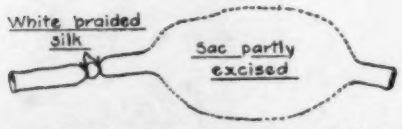

Fig. 27.—Ligatures applied in either Hunter's canal or the apex of Scarpa's triangle in Case 22.

4. SIXTEEN CASES OF POPLITEAL ANEURYSM

CASE 22.—*History.*—May 25, 1891; 41; man; colored; married; laborer. Aneurysm of the left popliteal artery of three years' duration. Syphilis at 20 years of age.

Symptoms and Physical Signs.—Large extravasation of blood; edema. History of three definite ruptures of the aneurysm into the tissues; nine months, four months and three weeks before operation. Paralysis of the internal popliteal nerve. No gangrene. Reddening of the skin in the popliteal space. Posterior tibial pulse not commented on. Heart normal. Blood pressure not recorded. Temperature, 101. Pulse of the aneurysm very slight on admission, but good before the first rupture.

Operation.—May 26. Dr. W. S. Halsted. Ligation of the femoral artery in Scarpa's triangle. Evacuation of clot and partial excision of aneurysmal sac. Two incisions — one in front, one behind. Both closed loosely without drainage.

Postoperative Course.—Wounds infected; irrigated with phenol. Healed by granulations. Paralysis of the nerve unchanged.

Result.—Well, July 19.

The technic used was green soap for five hours. Bath, 10 p. m., followed by wet dressing of phenol 1:80. Same dressings wet at 4 a. m. with mercuric chlorid, 1:1,000. Enema. No breakfast. Morphin, ⅙ grain (0.01 gm.), atropin 1/120 grain.

CASE 23.—*History.*—Sept. 30, 1895; 59; man; colored; married. Aneurysm of the left popliteal artery of sixteen years' duration, with rapid growth during the last seven months. Syphilis for twenty years.

Symptoms and Physical Signs.—The tumor remained stationary for about fifteen years. Some lameness was present. The vessels were sclerotic. The heart was a little larger than normal. There was no nerve paralysis. The pulse in the dorsalis pedis and posterior tibial arteries was gone. The aneurysm was pulseless.

Operation.—October 11. Dr. W. S. Halsted. Complete excision of a large popliteal aneurysm. Ligation of the popliteal vessels. Aneurysm arose from an articular branch. Three irrigations with mercuric chlorid, 1:1,000. Popliteal vessels tied and divided.

Postoperative Course.—Bloody stools, diarrhea, sore mouth. No gangrene.

Result.—Death, October 20, from mercuric chlorid poisoning.

Necropsy.—Arteriosclerosis; chronic endocarditis of the aortic and mitral valves.

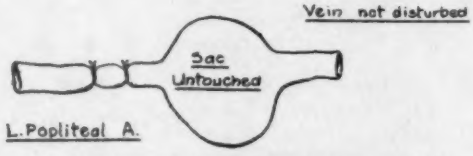

Fig. 28.—First operation in Case 25.

The popliteal vessels were almost obliterated by the pressure of the aneurysm. A tourniquet was reapplied just before the third irrigation; it may have been loose.

CASE 24.—*History.*—Jan. 20, 1896; 39; man; white; single; canner. Aneurysm of the right popliteal artery of four months' duration. Syphilis for sixteen years, with a short course of treatment with iodids.

Symptoms and Physical Signs.—The tumor filled the popliteal space. The heart was normal. The nerves and circulation of the foot were not impaired.

Operation.—January 30. Dr. W. S. Halsted. Complete excision of a large popliteal aneurysm. Irrigation with mercuric chlorid, 1:1,000. Vein not disturbed.

Postoperative Course.—The circulation was never impaired. The wound did not fill.

Result.—Well, February 27. Letter of April 17, 1922, returned; patient deceased.

CASE 25.—*History.*—July 12, 1898; 38; man; colored; married; barber. Aneurysm of the left popliteal artery of four or five years' duration. No history of syphilis.

Symptoms and Physical Signs.—Gradual increase in size until four weeks ago, since which time it has doubled. The heart was normal except a slight soft systolic murmur at the apex. The aneurysm stood out like an orange.

First Operation.—July 15. Dr. J. M. T. Finney. Ligation of the popliteal artery in the popliteal space, vessels not divided. Two ligatures one-half inch (1.27 cm.) apart. Vein not disturbed.

Second Operation.—July 30. Dr. J. M. T. Finney. Excision of the sac of aneurysm, large extravasated clot and necrotic tissue. Closure above and below; packed with iodoform gauze.

Postoperative Course.—A gangrenous area 2 inches (5 cm.) in diameter developed over the swelling. This sloughed into the clot and probably necessitated the second operation. Healing by granulations.

Result.—Well, September 2. Foot and leg did not slough. Some edema on discharge. No further history.

CASE 26.—*History.*—Aug. 12, 1901; 38; man; white; married; ship-joiner. Aneurysm of the left popliteal artery of two years' duration. No history of syphilis; gonorrheal infection once.

Symptoms and Physical Signs.—Aneurysm came after tight bandaging of the leg. Mass was 7 by 8 cm., and was expansile. The heart was normal. There was no record of nerve disturbances.

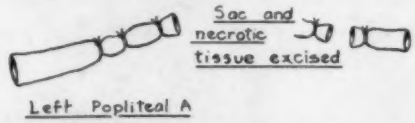

Fig. 29.—Second operation in Case 25.

Fig. 30.—Operation in Case 26; aneurysmal sac not disturbed.

Operation.—August 22. Dr. J. M. T. Finney. Ligation of the popliteal artery for popliteal aneurysm.

Postoperative Course.—Healing by first intention. No pulse in the foot on discharge. The aneurysm was dead.

Result.—August 28, well. No further history.

CASE 27.—*History.*—Aug. 16, 1901; 42; man; colored; married; laborer. Aneurysm of the right popliteal artery for six months. Syphilis for seven or eight years; untreated.

Symptoms and Physical Signs.—Had rheumatism in the legs for several months previous to swelling. Heart normal. Aneurysm was "enormous" no other description.

Operation.—August 23. Dr. M. B. Tinker. Ligation of the popliteal artery in its first portion. Closure with silver wire.

Postoperative Course.—A little slough, the size of a dime, appeared in the line of incision. Gangrene of the toes and foot. The patient went home against advice.

Result.—October 16, aneurysm clotted, but there was gangrene of the foot. No further history.

Why there was no amputation is not said in the history. Would this patient have gotten gangrene if the sac had been incised and the clot evacuated?

CASE 28.—*History*—Oct. 6, 1903; 40; man; colored; married; stevedore. Aneurysm of the left popliteal artery, of one year's duration. No history of syphilis; gonorrheal infection for eighteen or twenty years.

Symptoms and Physical Signs.—Sharp pains for a year or more. Severe pain and pulsation for four weeks. Tumor 10 by 8 cm.; expansile. Pulse in this foot much less than in the other. Scar on the penis.

Operation.—October 28. Dr. W. S. Halsted. Incision of aneurysmal sac and suture of opening of popliteal artery. Ligation of the femoral artery in Scarpa's triangle. Small iodoform gauze pack. Vein undisturbed.

Postoperative Course.—Healing of upper wound by first intention; lower wound without infection.

Result.—Well, December 1. No further history.

The sac was partly obliterated by sutures. The gauze pack was used because one of these sutures stuck a vein. The femoral artery was ligated in Scarpa's triangle because the mouths of the openings into the aneurysm were too friable to hold sutures.

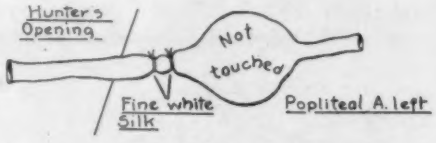

Fig. 31.—Operation in Case 27.

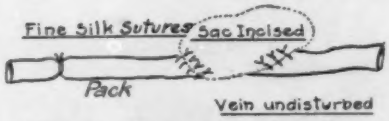

Fig. 32.—Operation in Case 28.

CASE 29.—*History.*—May 5, 1906; 40; man; colored; married; laborer. Aneurysm of the left popliteal artery of fifteen months' duration. Gonorrheal infection twice at 18 and 37; syphilis as 17 (?).

Symptoms and Physical Signs.—Rather rapid increase in the size of the aneurysm in the last month. The heart was normal. The pulse in the foot was felt. There was slight swelling of the leg.

Operation.—May 11. Dr. W. S. Halsted. Occlusion with an aluminum band of the femoral artery in Hunter's canal. Closure with silver wire.

Postoperative Course.—The pulse never returned in the sac or in the foot.

Result.—Well, June 21. No further history.

CASE 30.—*History.*—July 26, 1908; 36; man; colored; widower; laborer. Aneurysm of the left popliteal artery of seven months' duration. Syphilis for seven years.

Symptoms and Physical Signs.—Swelling began after a bruise to the knee. Knee partly flexed. Heart normal. No pulse in the left foot. Faint pulse in right dorsalis pedis. Large swelling. Only a little edema of the left lower leg. False aneurysm.

First Operation.—August 6. Dr. J. C. Bloodgood. Antyllus' operation plus ligature of a thrombosed vein. Closure with catgut. One small drain. Artery so sclerotic silk ligatures cut through. No attempt to obliterate the sac.

Second Operation.—August 17. Dr. R. T. Miller. Amputation of left leg at knee joint.

Postoperative Course.—Gangrene appeared promptly after the first operation. The wound was clean. After the second operation recovery was uninterrupted.

Result.—Well (amputation of leg), September 6. No further history.

The operator had in mind to do a reconstructive Matas' operation, but could not on account of sclerotic vessels.

CASE 31.—*History.*—April 13, 1911; 52; man; colored; married; laborer. Aneurysm of the left popliteal artery of three and one-half months' duration. Syphilis for thirty years; Wassermann reaction positive.

Symptoms and Physical Signs.—Onset one and one-half months after a blow on the knee with a piece of lumber. Gradual growth. Tumor about the size of "one's fist"; 16 by 15 cm. Leg a little swollen. No pulse in the foot. Foot partly anesthetic.

First Operation.—April 21. Dr. J. C. Bloodgood. Matas' reconstructive aneurysmorrhaphy. Lateral suture of vein. Tape left about artery for emergency. Catgut closure. "Vessel probably clotted before the wound was closed."

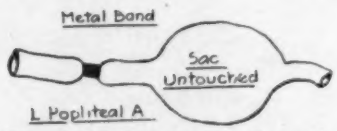

Fig. 33.—Operation in Case 29.

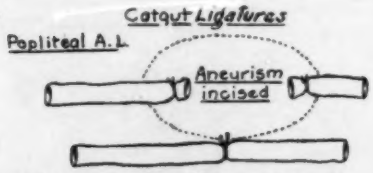

Fig. 34.—Operation in Case 30.

Second Operation.—April 23, 1911. Dr. C. M. Remsen. Amputation at middle of thigh for gas gangrene. Wound left open.

Third Operation.—May 29. Dr. W. D. Gatch. Repair of amputation stump.

Postoperative Course.—The pulse did not return in the foot after operation. Gangrene and gas bacillus infection. After prolonged suppuration the amputation wound healed. The syphilis was not treated.

Result.—Well (leg amputated), June 20. No further history.

CASE 32.—*History.*—Dec. 9, 1911; 35; man; colored; widower; laborer. Aneurysm of the left popliteal artery of one month's duration. No history of syphilis or gonorrheal infection but the Wassermann reaction was strongly positive.

Symptoms and Physical Signs.—No injury. Acute swelling from knee to ankle, subsiding and leaving a pulsating knot. Marked pain. Heart normal. Tumor filled popliteal space; 8.5 by 6.5 cm. Slight swelling of the left leg below the knee. No pulse in either foot. Left foot a little colder than the right.

Operation.—December 16. Dr. W. S. Halsted. Application of ligatures to popliteal artery. Marked occlusion but not complete. Silk used. Closure with silk, no drain. Pulse in the aneurysm made to disappear by the ligatures.

Postoperative Course.—No pulse was noted in the aneurysm or foot vessels after operation. The aneurysm clotted and became smaller. No sensory, motor or circulatory disturbances in the foot. Unilateral sweating of the sole of the left foot was noted on one occasion. The temperature of the left foot was never higher than that of the right, usually a little lower. The syphilis was not treated.

Result.—Well, Jan. 21, 1912. No further history.

Partial occlusion by ligatures was done—first one of heavy silk and not so constricting as the second one of fine silk. I imagine that the occlusion was complete, though the operative note says "not complete by any means."

CASE 33.—*History.*—May 22, 1912; 24; man; white; single. Aneurysm of the right popliteal artery, four years after injury, with symptoms of one month's duration. No history of syphilis; Wassermann reaction negative. Gunshot injury four years before admission.

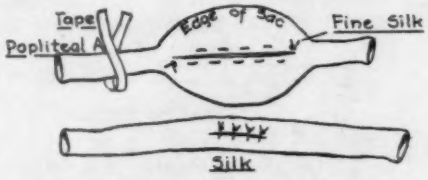

Fig. 35.—Operation in Case 31.

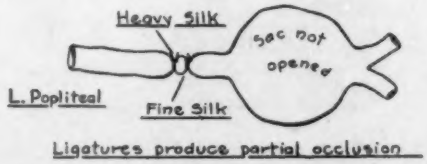

Fig. 36.—Operation in Case 32.

Symptoms and Physical Signs.—Shot four years before admission through the right popliteal space. Sharp bleeding, but no trouble afterward until one month before. Swelling, early gangrene of toes, anesthesia and numbness rapidly developed. Pulse in the foot. Scar in popliteal space and a small, nonpulsating mass. Some cyanosis and coldness of both hands and left foot. Heart normal.

First Operation.—May 24. Dr. G. J. Heuer. Exploration of popliteal space for a small healed saccular aneurysm. Nothing done. Closure with silk.

Second Operation.—June 28. Dr. Emil Goetsch. Incision curettage and drainage of infected wound of popliteal space.

Postoperative Course.—Infection of the wound leading to drainage three days after operation. Secondary hemorrhage, June 8; from 200 to 300 c.c. of blood. Secondary hemorrhage, June 15; 200 c.c. of blood. Prompt healing after second operation. Toes also healed, but they were nearly well at the time of the first operation.

Result.—Well, July 27. No further history.

This may possibly be a case of Raynaud's disease. The bullet producing the small healed aneurysm may have injured the nerve. The healed aneurysm was the size of a walnut.

CASE 34.—*History.*—Sept. 13, 1912; 25; man; colored; married; musician. Aneurysm of left popliteal artery of three months' duration. Syphilis from three to eight years; gonorrhea twice; Wassermann reaction positive.

Symptoms and Physical Signs.—Heart normal. No injury. Pain was the first sign. Swelling was present for seven weeks. Anesthesia over outer aspect of the lower leg. A very faint pulse in the foot. The feet were of the same temperature. Edema over the aneurysm and some swelling of the leg.

Operation.—September 21. Dr. G. J. Heuer. Obliterating endo-aneurysmorrhaphy for popliteal aneurysm.

Postoperative Course.—Paralysis of both external and internal popliteal nerves on the left side (probably operative). Anesthesia of the skin a little increased. Circulation remained good. No return of pulse in the foot. No comment on surface temperature.

Result.—Well, but left foot paralyzed, November 11. No further history.

The diagnosis was not definitely made before operation: first an exploratory incision on the inner side; then a tourniquet and a second incision in the

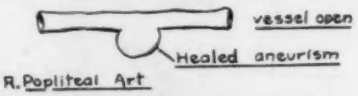

Fig. 37.—Healed aneurysm in Case 33.

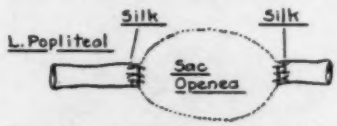

Fig. 38.—Operation in Case 34.

popliteal space. The nerves may have been cut, or possibly paralyzed by anemia due to the tourniquet.

CASE 35.—*History.*—April 29, 1919; 64; man; white; married; farmer. Aneurysm of the left popliteal artery of one year's duration; arteriosclerotic. No history of syphilis; Wassermann reaction negative.

Symptoms and Physical Signs.—Heart normal. Aneurysm an accidental discovery. No pain, anesthesia or discomfort. Tumor the size of a tennis ball. No sensory disturbances. Pulse equal in both dorsalis pedis arteries, but not felt in posterior tibial vessels. Left leg below the knee warmer than the right.

Operation.—May 5. Dr. M. R. Reid. Lexer's ideal operation. Calcified and partially thrombosed aneurysm excised. End-to-end anastomosis of the artery.

Postoperative Course.—No embarrassment to circulation. No sensory changes. No accurate observations on surface temperature. No pulse in either foot at time of discharge.

Result.—Well, June 1. No further history.

Although the aneurysm was sclerosed, the vessels that were anastomosed were not. The vein and nerve were uninjured. Almost no constriction was caused by suture of the vessel, the pulse coming through beautifully.

CASE 36.—*History.*—Oct. 27, 1919; 36; man; colored; driver. Aneurysm of the left popliteal artery of two months' duration. Syphilis for ten years, with secondary eruption. Wassermann reaction positive (?).

Symptoms and Physical Signs.—Heart enlarged. Aortic insufficiency. Syphilitic aortitis. Precordial pain. Very large ruptured popliteal aneurysm with edema of the skin. Foot numb. Marked flexion of the leg. Severe pain. The skin over the tumor blistered by iodin. No pulse in the foot. Foot cold. Blood dissecting half way to the foot.

Operation.—October 27. Dr. M. R. Reid. Lexer's ideal operation with end-to-end anastomosis of artery. No drain. Small rent in the vein was sutured. Pulse returned below suture on removing the tourniquet. Flexion of the leg made arterial suture possible. Muscles and subcutaneous tissues almost gangrenous.

Postoperative Course.—Mild infection of the wound. Some twitchings of extensor muscles of the toes for a day. No gangrene of the toes; no permanent sensory or motor disurbances. Surface temperature lower in the big toe for thirty-six hours; after that the entire foot "was as warm" as the right. Many injections of arsphenamin.

Result.—Well, Jan. 6, 1920. Leg perfectly well, March 23, 1921, when admitted for aortic insufficiency; myocardial insufficiency.

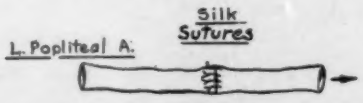

Fig. 39.—End-to-end anastomosis of the popliteal artery after excision of the aneurysm in Case 35.

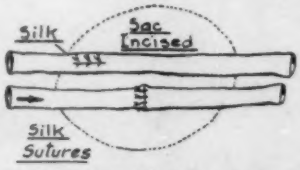

Fig. 40.—End-to-end anastomosis of the artery within the aneurysmal sac in Case 36.

May 18, 1922, from the more or less unintelligible reply we concluded that there was no loss of power. The patient spoke of a sore on the foot and some pain in the calf of the leg.

The anastomosis certainly worked long enough to save the life of the leg, which was practically dead at the time of operation.

CASE 37.—*History.*—Dec. 13, 1919; 30; man; colored; porter. Aneurysm of the right popliteal artery of three months' duration. Syphilis for twenty years. Wassermann reaction positive (?).

Symptoms and Physical Signs.—Temperature, 103. White blood cells, 20,000. Very large infected false aneurysm with gangrene of the leg two thirds of the way to the knee. Foot dead and icy cold. Heart normal.

Operation.—December 13. Dr. A. Taylor. Amputation of the right leg for a large infected aneurysm.

Postoperative Course.—Prompt healing. Syphilitic treatment given.

Result.—Well, Jan. 7, 1920. No further history.

Infection so obscured this case that an aneurysm was not suspected until the time of operation.

5. FIVE CASES OF INNOMINATE ANEURYSM

CASE 38.—*History.*—Jan. 21, 1907; 51; man; colored; married; laborer. Aneurysm of the innominate artery of one month's duration. No history of syphilis; gonorrhea at the age of 19.

Symptoms and Physical Signs.—The tumor increased from a small lump to the size of a baseball in one month. There was numbness in the right hand. The right pupil was smaller than the left. The symptoms began with a cough, then pain in the neck, ear and chest. The heart was possibly enlarged. The tumor measured vertically 8.5 by 11 cm. The right radial pulse was more compressible than the left. There is no record of the strength of the hand before operation.

First Operation.—February 2. Dr. W. S. Halsted. Ligation of the innominate artery for aneurysm involving the subclavian artery. Three heavy braided white silk ligatures tied close together, the most distal one completely occluding the artery. Small iodoform pack placed to a point of rupture in the pleura.

Second Operation.—February 20. Dr. W. S. Halsted. Ligation, partial, of the common carotid artery with aluminum band above an aneurysm involving

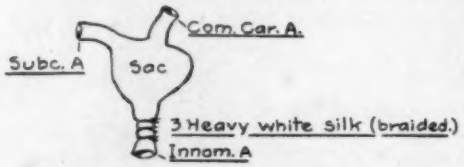

Fig. 41.—Operation in Case 38: the two lower ligatures on the innominate artery are only partially occluding the lumen—a procedure much to be condemned.

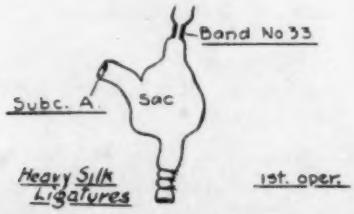

Fig. 42 (Case 38).—Ligation of the innominate artery at the first operation; partial occlusion of the common carotid artery with a band at the second operation.

the subclavian, common carotid and innominate arteries. Band No. 33, 8 mm. wide. It almost occluded the artery just below the bifurcation.

Postoperative Course.—1. Pulse noted in the wrist by 5 p. m. on the day of operation, also in the temporal. No sensory disturbances developed. Some edema of the arm, but this subsided markedly before the second operation. The grip was weaker but not a great deal. The pupil was small. The aneurysm continued to pulsate with two-thirds the former force; it became smaller, 7 by 7 cm.

2. "Slight change caused by the band at the time of operation." The aneurysm was unimproved by the second operation. It increased in size. The grip in the hand became weaker.

Blood Pressure	February 3 11 a. m.	February 20 3 p. m.	8 p. m.
Right arm	65	100	85
Left arm	124	145	145
Left leg	...	155	...

No sensory or trophic disturbances.

Result.—Improved (?), June 11, 1907. Died, Jan. 1, 1908, pneumonia. Necropsy was refused. The patient's wife said that the aneurysm stopped pulsating and became hard before death.

CASE 39.—*History.*—Oct. 26, 1909; 60; woman; white; married; housewife. Aneurysm of the innominate and right subclavian arteries of nineteen months' duration. No history of syphilis; Wassermann reaction negative.

Symptoms and Physical Signs.—Pain in the head and neck and through the chest, and in the right arm. Pulse, sensation, blood pressure and power the same in both arms. Heart normal. Aneurysm 5 cm. in diameter just above the inner end of the clavicle. Blood pressure, 220.

Operation.—November 3. Dr. W. S. Halsted. Application of a band to the right carotid artery for dilatation of the innominate and subclavian arteries. No. 32 metal was used.

Fig. 43.—Band applied to the common carotid artery for enlarged and tortuous subclavian and innominate arteries in Case 39. At the time of operation there was thought to be a true aneurysm of the innominate artery.

Postoperative Course.—Pulse returned promptly in the temporal; however, it remained less in the carotid distal to the band. The symptoms were considerably relieved, but the mass was not much changed.

Result.—Improved, December 8.

Jan. 18, 1915, the patient reported that she had been greatly relieved until one year before, since which time she had had pain in the head, arms and neck. The condition was essentially the same except that the vessel was a little more tortuous and bigger. Slight cyanosis of the right hand. Right radial pulse weaker than the left. Neither hand easily fatigued. Carotid pulse on the right indistinctly palpable.

Jan. 3, 1921, my examination showed hypertension, arteriosclerosis, auricular fibrillation, cardiac hypertrophy. No essential change in the innominate. Right carotid obliterated at the site of the band. Temporal pulses equal. Obliteration of the left carotid pulse stopped both temporal pulses.

May 19, admitted for a burn of the chest wall. No change in the condition of the vascular system noted.

This was not a true aneurysm; simply a dilatation and tortuosity of the innominate and subclavian arteries. Band applied distally to relieve pressure in the head, and thus possibly the pain.

CASE 40.—*History.*—June 6, 1918; 45; man; white; married; merchant. Aneurysm of the innominate artery of two years' duration. Gave no history of syphilis but Wassermann reaction positive. Gonorrheal infection.

Symptoms and Physical Signs.—Severe pain in the hand and occiput for two years before the swelling appeared. One year and ten months before, operation in Atlanta: "Carotid and subclavian tied distally to aneurysm." No relief. No ptosis. Pupils equal. Aneurysm eroding through the sternoclavicular articulation.

Operation.—June 15. Dr. M. R. Reid. Attempt to ligate the innominate artery for aneurysm. Patient died before the ligature could be placed. Death apparently due to pulling on the arch of the aorta.

Postoperative Course.—The innominate artery at its junction with the aorta was bigger than the aorta and very sclerotic. A ligature was about to be placed here when the patient died.

Result.—Death, June 15.

Freeing the aneurysm from the innominate vein, vena cava, etc., was very exciting and difficult. We had learned from experiments on dogs that pulling on the arch of the aorta is dangerous. In this way a dog's heart can be stopped easily.

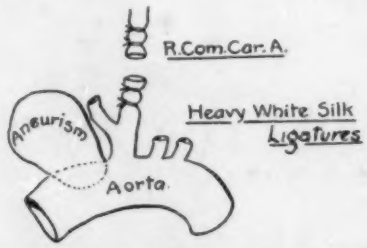

Fig. 44.—Aneurysm of the arch of the aorta mistaken for aneurysm of the innominate artery in Case 42.

CASE 41.—*History.*—Sept. 14, 1921; 72; man; white; widower; farmer. Aneurysm of the innominate artery of one year's duration. No history of syphilis, but Wassermann reaction positive. Gonorrheal infection.

Symptoms and Physical Signs.—Marked myocardial insufficiency, with shortness of breath, etc. Aorta dilated. Arteriosclerosis. The innominate dilatation was about the size of a walnut.

Treatment.—The patient was transferred to the medical service for treatment of cardiac condition which was causing the shortness of breath, but the treatment was not given.

It was believed that the aneurysm probably would not shorten his life. It impressed one as being a tortuous, sclerotic artery. Operation was not advised.

CASE 42.—*History.*—Jan. 10, 1895; 29; man; colored; married; janitor. Aneurysm of innominate artery; correct diagnosis: arch of the aorta. Duration one year or more. Syphilis for four years with no history of treatment.

Symptoms and Physical Signs.—Heart about normal size. Temporal and radial pulses reported equal. Weakness of the right arm. Circulation good. Blood streaked sputum. Aneurysm pointing at the inner end of the clavicle, 6.5 by 5 cm.

Operation.—January 11. Dr. W. S. Halsted. Ligation and division between double ligatures of the right common carotid artery. Irrigations. Silver wire closure.

Postoperative Course.—Death three hours after operation due to rupture of aneurysm into bronchus. Left arm and leg paralyzed by operation.

Result.—Death, January 11.

An aneurysm of the arch mistaken for the innominate because of the pointing place.

Necropsy.—Aneurysm of arch of aorta; chronic endocarditis of the aortic valve and of the left ventricle; cardiac hypertrophy; arteriosclerosis.

6. THIRTEEN CASES OF CAROTID ANEURYSM

CASE 43.—*History.*—Oct. 3, 1895; 38; man; white; single; salesman. Aneurysm of the left common and external carotid arteries of five years' duration. No history of syphilis; gonorrhea several times.

Symptoms and Physical Signs.—Decided increase in the last year, rapid in the last six months. Heart somewhat enlarged. Tumor 3 by 9 by 6 cm.

Operation.—October 22. Dr. W. S. Halsted. Ligation with silk and division of the left common carotid artery. Wound not irrigated. Closure with silver wire.

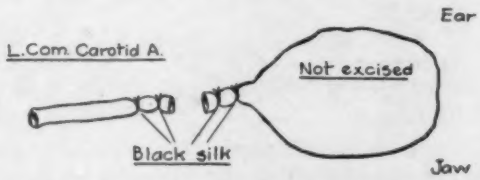

Fig. 45.—Operation in Case 43. The aneurysm remained solid and apparently dead for more than a year after this operation; then it grew and ruptured spontaneously.

Postoperative Course.—December 4, all pulsation had ceased by this time. December, 1896, tumor solid. No pulsation. No decrease in size.

Result.—Improved, December 6. Death, May 20, 1897, from rupture of the sac.

Aneurysm not excised because it extended high in the neck and it was thought that securing the vessels above would be too difficult.

CASE 44.—*History.*—May 18, 1906; 34; man; colored; married; laborer. Aneurysm of the left carotid artery of five years' duration. Syphilis for three years with treatment for four weeks. No secondary eruption. Gonorrheal infection.

Symptoms and Physical Signs.—Rapid enlargement of aneurysm for the last six months associated with paroxysms of coughing. Poor sight in the left eye for six months. Voice changed. R. C. D. 12.5 cm. to the left, 3.5 cm. to the right. Aneurysm on a level with the cricoid cartilage. Left pupil a little smaller than the right. Left vocal cord paralyzed. Tumor remained small for four and one-half years.

Operation.—June 2. Dr. W. S. Halsted. Occlusion of left common carotid with an aluminum band. Silver wire closure.

Postoperative Course.—Sudden hemiparesis and hemianesthesia with sensory aphasia eight days after operation. Vision, however, unaffected. Paralysis almost gone by June 30. Left pupil remained small. Face, arms and legs were involved in the paralysis.

Result.—Well, July 5. No further history.

Dr. Thomas thought there was an occlusion, possibly by embolus, of the left middle cerebral artery. Band not removed.

Case 45.—*History.*—Feb. 14, 1907; 36; woman; white; married; housewife. Aneurysm of the left common carotid, with swelling for five or six weeks before admission. No history of syphilis.

Symptoms and Physical Signs.—For two years the patient had had occasional pain about the ear. Slight pain in the left arm for some time. Tumor at the site of the bifurcation. Heart 11 cm. to the left, 1 cm. to the right of the midsternal line.

Operation.—February 15. Dr. W. S. Halsted. Partial ligation of the common carotid artery just below the ventricle, for a small aneurysmal dilatation of the ventricle. An aluminum band, No. 32, width 5 mm. was used. Band tightened until there was the faintest pulse in the external and internal carotid arteries.

Postoperative Course.—Six days after operation, weakness of the face and right arm with exaggerated reflexes were noted. The right pupil was larger. The patient was drowsy and her memory was poor. Slight ptosis of the right

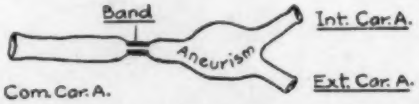

Fig. 46.—Operation in Case 45: partial occlusion of the common carotid artery with an aluminum band, which was followed six days later by rather pronounced temporary cerebral disturbances.

lid. Right grip markedly weak. Dizziness and headache. Temporal pulse, at first weak, later became almost as strong as the right. Hemiparesis disappeared and the grip became normal. Memory only a little impaired on discharge.

Result.—Well, March 8.

March 16, 1916, the temporal pulse was barely perceptible. Aneurysm cured. Band palpable. Faint pulse in the left ventricle. No bruit. Right pupil a little larger than the left. Blood pressure, 232. Subjectively well. Grip good. No paresthesia.

May 12, 1922, there was no evidence of any carotid aneurysm. The patient remained well except for hypertension.

Case 46.—*History.*—Sept. 19, 1910; 53; man; colored; single; laborer. Aneurysm of the left carotid, probably the internal, of nine months' duration. Syphilis for four years; Wassermann reaction strongly positive.

Symptoms and Physical Signs.—Onset of the swelling after a severe coughing spell. Gradual increase in size. Heart slightly enlarged, 13 cm. to the left. Aneurysm measured vertically 8.5 cm., transversely 10.5 cm. Center of the tumor about at the bifurcation of the carotid. Left pupil small. Paralysis of the left hypoglossal nerve. Aneurysm pushed in the pharyngeal wall and floor of the mouth. Sudden respiratory difficulty developed, September 24.

First Operation.—September 24. Dr. John Churchman. Tracheotomy for obstruction to respiration secondary to aneurysm of the neck.

Second Operation.—September 30. Dr. Churchman. Ligation of the left common carotid artery for aneurysm. Small protective drain.

Postoperative Course.—Return of the pulse in the aneurysm and the bruit noted on the morning after operation. Much relief for ten days. Severe secondary hemorrhage from the wound, October 9.

Result.—Sudden death, October 10, probably due to embolus. No paralysis of the body.

Necropsy.—Careful search for embolus not made.

Only one ligature of silk was used. The aneurysm was very large.

CASE 47.—*History.*—June 1, 1911; 61; man; white; single; physician. Aneurysm of the right external carotid artery of three years' duration. Syphilitic and gonorrheal infections. Wassermann reaction not recorded.

Symptoms and Physical Signs.—Accidental discovery of swelling. Very slow growth. Heart normal.

Operation.—June 2. Dr. W. S. Halsted. Application of metallic band to right external carotid artery. Not quite complete occlusion.

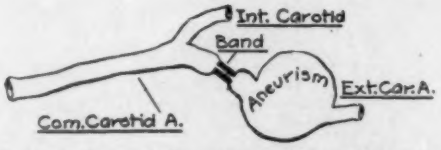

Fig. 47.—Partial occlusion of the external carotid artery with a metallic band in Case 47.

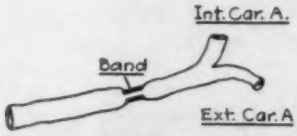

Fig. 48.—Operation in Case 48. This band cut through and a large hematoma of the neck resulted. The patient's blood pressure was 200.

Postoperative Course.—Slight pulsation persisted, also tenderness. On discharge, occlusion of the right common carotid artery stopped this pulsation, showing that blood passed beneath the band.

Result.—Improved, June 15.

May 16, 1922 (letter), the aneurysm was now very small and caused no trouble; no pulsation in it. Health good.

CASE 48.—*History.*—May 22, 1912; 54; woman; white; single; housekeeper. Aneurysm of the right carotid artery of nine months' duration. No history of syphilis.

Symptoms and Physical Signs.—Onset with tinnitus and hearing of heart beats in the ear; relieved by turning the head far to the right or pressing on the common carotid artery. No tumor noted. Heart normal. Blood pressure, 200. No aneurysm discovered by examination. Arteriosclerosis.

Operation.—May 23. Dr. W. S. Halsted. Application of band to right common carotid artery for tinnitus in the right ear. Vessel almost occluded. Vessel sclerotic. Narrow band used.

Postoperative Course.—The band cut through seventeen days after operation. Large sterile hematoma in the neck, opened and drained by Dr. Follis. After this the patient developed acute nephritis, pleurisy and bronchopneumonia. Until the band cut through the patient was greatly, though not entirely, relieved of her tinnitus.

Result.—Death, June 23. No necropsy.

CASE 49.—*History.*—Sept. 30, 1914; 31; man; colored; single; laborer. Aneurysm of the right common carotid of five months' duration. Syphilis for ten years with secondary manifestations; Wassermann reaction positive. Short treatment.

Symptoms and Physical Signs.—On first admission: Tumor 13 cm. vertically by 11.5 cm. Small pupil. Ptosis. Heart 10.5 cm. to the left; sounds clear. Tumor grew under observation before operation.

Operation.—October 12. Dr. W. S. Halsted. Ligation of the common carotid artery for aneurysm. Resection of the inner end of the clavicle. Pulsation still present but much less (nonexpansile), noted when ligature was tied.

Postoperative Course.—The tumor became harder and the pulsation less, disappearing entirely, November 20, at which time the tumor became much softer. Discharged with tumor smaller and no pulsation. Headache (mostly right side) for two or three days. No paralyses. Ptosis a little less. Given treatment for syphilis.

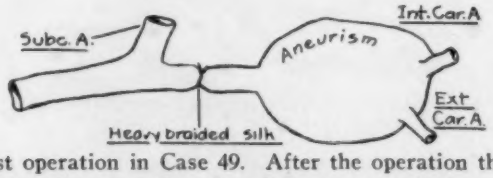

Fig. 49.—First operation in Case 49. After the operation the aneurysm was apparently well for three months; then it began to pulsate again.

Result.—Well, November 25. The patient was readmitted, March 4, 1915, with the following symptoms: Pulsation had reappeared in the swelling three weeks before (patient). Increase in size of tumor. Pupils equal. Ptosis. Visible and palpable heaving pulsation. Right temporal pulse just palpable.

Second Operation.—March 23, 1915. Dr. W. S. Halsted. Ligation of the blood vessels of the neck distal to a carotid aneurysm. Internal carotid greatly thickened and reduced in size. Blood flowed, did not spurt, on dividing it.

Postoperative Course.—Patient left the hospital with a slow, heaving pulsation in the tumor.

Result.—Improved, April 6.

When I examined the patient, Oct. 19, 1916, the tumor was still pulsating; the size was a little smaller.

April 21, 1918, the tumor was a little larger; pulsating (slow expansile).

May 20, 1920, the aneurysm was softer, bigger and a little more active. Systolic bruit. Ptosis. Pupils equal. No temporal pulse. Removal advised.

In February, 1922, admitted to Mercy Hospital, Baltimore, with an enormous aneurysm causing obstructive symptoms. Death from rupture of the aneurysm into the trachea and pharynx.

CASE 50.—*History.*—June 3, 1915; 46; woman; white; married; housewife. Aneurysm of the right carotid artery of one month's duration. Arteriosclerosis. High blood pressure. Wassermann reaction negative.

Symptoms and Physical Signs.—Heart a little enlarged—12 cm. to the left, 3 cm. to the right. Systolic murmur. Blood pressure, 220.

Operation.—June 5. Dr. W. S. Halsted. Application of metallic band to common carotid artery above aneurysm. Partial occlusion. Band rolled until thrill just disappeared. Temporal pulse quickly returned.

Postoperative Course.—No cerebral symptoms. No bruit. Only slight change in aneurysm. Vessel wall not commented on as being very sclerotic.

Result.—Improved, June 12.

October 21, tumor about the same. No thrill or bruit. Headaches much relieved until recently. Blood pressure, 195.

Nov. 14-Nov. 25, 1915, came to hospital for rest and examination. Neck about the same. Loud bruit above the band. High tension. Possibly a sacculated aneurysm of the arch. No further history.

This was probably a case of a tortuous sclerotic vessel forced into an S shape.

CASE 51.—*History.*—July 21, 1916; 38; man; colored; married; porter. Aneurysm of the right common carotid of two years' duration. Syphilis for ten years with no treatment. Gonorrheal infection. Wassermann reaction strongly positive.

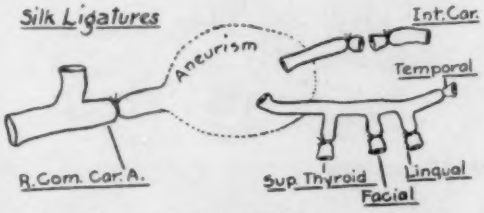

Fig. 50.—Second operation in Case 49 five months after the first. This did not have much effect on the aneurysm.

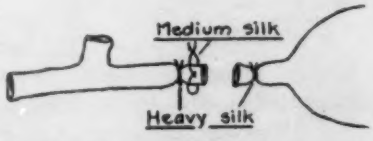

Fig. 51.—First operation in Case 51.

Symptoms and Physical Signs.—Right side of the face dry. Right pupil contracted. Heart normal. Weakness of the right shoulder. Right forearm as strong as the left. Rapid increase in the tumor during the last three months. Tumor 11 by 14 cm.

First Operation.—July 27. Dr. R. H. Follis. Ligation and division of the right common carotid artery for aneurysm.

Second Operation.—August 22. Dr. R. H. Follis. Excision of a carotid aneurysm, right.

Postoperative Course.—After the first operation the aneurysm stopped pulsating and became a little smaller. No cerebral disturbances.

After the second operation there was some pain in the right side of the head. No paralysis. Pupil remained contracted. Right temporal pulse returned. The sac was dead; it was filled with clot so that when opened it did not bleed. Excision easily done.

Result.—Well, September 5. No further history.

I think it entirely probable that this aneurysm would have recurred if it had not been excised.

CASE 52.—*History.*—Jan. 17, 1917; 40; man; colored; married; stevedore. Aneurysm of the right carotid artery of seventeen days' duration. Syphilis twenty years; Wassermann reaction strongly positive.

Symptoms and Physical Signs.—Heart normal. Onset of swelling was after a scuffle in which the neck was choked. Rapid growth. Size 9 by 6 cm. Situation in upper half of the neck. Right vocal cord paralyzed.

Operation.—January 25. Dr. W. S. Halsted. Occlusion of right common carotid artery with an aluminum band.

Postoperative Course.—Return of pulsation (very faint) on the evening of the operation; still present on discharge. Temporal pulse felt faintly at completion of operation; very well, though variably, thereafter. No cerebral disturbances. A little unilateral headache. Right side of tongue temporarily paralyzed.

Result.—Improved, May 3. No further history.

The patient was given numerous injections of arsphenamin but the Wassermann reaction remained positive.

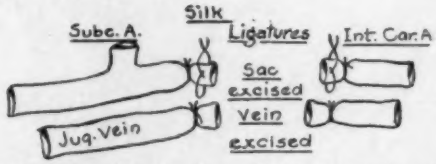

Fig. 52.—Second operation in Case 51 four weeks after the first.

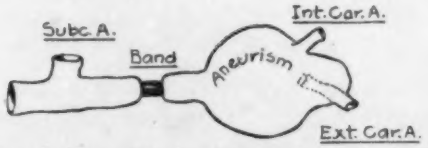

Fig. 53.—Operation in Case 52; improvement resulted. The patient refused to permit excision of the aneurysm after the application of the band.

CASE 53.—*History.*—Aug. 3, 1917; 46; man; colored; widower; laborer. Aneurysm of the left carotid artery of one and one-half years' duration. Syphilis for two years without treatment.

Symptoms and Physical Signs.—Heart normal. No history of injury to the neck. Rapid increase in size of aneurysm in the last three weeks. Pupils equal. No ptosis. Tumor extended to 1.5 cm. of clavicle; measured 9 by 10 cm. Left vocal cord paralyzed.

Operation.—August 16. Dr. R. H. Follis. Ligation of the left common carotid and division of it.

Postoperative Course.—Prompt return of temporal pulse. Slow return of a weak aneurysmal pulse. Slight decrease in size of tumor. No cerebral disturbances. No changes in the eyes or lids. Patient refused excision or further treatment. Left hospital with a slow pulsation of tumor.

Result.—Improved, August 26.

Examination, June 1, 1922, showed the patient entirely well. The aneurysm had disappeared.

CASE 54.—History.—Jan. 28, 1918; 45; man; colored; married; laborer. Aneurysm of the right common carotid artery of three years' duration. Syphilis for twenty years; Wassermann reaction positive; gonorrheal infection.

Symptoms and Physical Signs.—Pain in the right sternoclavicular region. Difficult swallowing. Right pupil small. Slight ptosis. Tumor behind the clavicle; size 6.5 by 4.5 cm. Heart normal.

Operation.—January 29. Dr. W. S. Halsted. Ligation of the innominate artery. Resection of the clavicle, part of the sternum and part of the first rib.

Postoperative Course.—Pulse noted at the wrist the afternoon of the operation, becoming countable by 8 p. m. Definite pulse in the carotid and in the aneurysm the day after operation, also in the wrist and temporal. January 30, blood pressure left arm 122/75; right arm 90/75. February 8, no pulse in the aneurysm or the carotid; good pulse at the wrist. On discharge, aneurysm pulseless, small pupil, ptosis. Good pulse at the wrist and in the temple. Bruit over the tumor. No cerebral disturbances. No trophic or sensory changes in the arm.

Result.—Well, March 5 (letter).

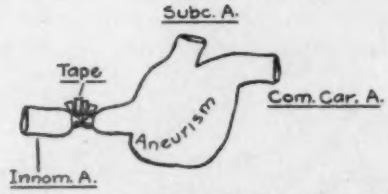

Fig. 54.—First operation in Case 54.

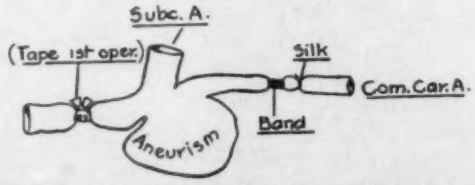

Fig. 55.—Second operation in Case 54 two months after the first. At this time the carotid artery was almost flat and was pulseless.

March 25, the patient returned. Return of pulsation in the tumor was noted soon after the patient left the hospital. The tumor had grown to 7 by 6.5 cm. Definite pulse in the aneurysm. Carotid artery pulseless, but felt as a cord. Bruit present. Radial pulse well felt; also the temporal. Arm not swollen. No paralysis; no anesthesia. Blood pressure, right 83/70, left 105/65.

Second Operation.—April 9. Dr. W. S. Halsted. Ligation of the common carotid artery with a band and ligature. The common carotid was small, thick walled and contained no pulse. Hard to see how occluding it would help. Yet at the conclusion of the operation, no pulse could be felt in the aneurysm. The carotid artery was almost flat.

Postoperative Course.—No return of pulsation in the aneurysm. Slight bruit on discharge. Intensive antisyphilitic treatment.

Result.—Well, April 28.

May 6, aneurysm 5 cm. in diameter, pulseless. Astonishing that the ligation of the flat artery should have produced such a result.

August 23 (letter), well; knot smaller, nonpulsating.

April 12, 1919, observation showed aneurysm gone except for a small cord the size of the little finger. It was entirely cured. Wassermann reaction negative. Good use and grip in both hands.

Jan. 23, 1920 (letter), entirely well.

May 15, 1922 (letter), well; works hard; no evidence of an aneurysm.

CASE 55.—*History.*—Aug. 27, 1919; 61; woman; white; married; housewife. Aneurysm of the right internal carotid of one year's duration. No history of syphilis; Wassermann reaction negative.

Symptoms and Physical Signs.—Began with a tickling sensation in the throat. Swelling protruded into the pharynx, resembling a peritonsillar abscess. Eight weeks before admission an incision had been made into the swelling. Pulsating swelling in the mouth involving the soft palate and tonsil, not showing externally.

Operation.—September 2. Dr. M. R. Reid. Ligation of the right internal carotid artery for pulsating peritonsillar aneurysm. Occlusion of the external carotid had no effect on the aneurysm.

Postoperative Course.—Pulsation (much reduced by the operation) promptly returned and lasted for eight days. During this time there was right-sided headache. Then the aneurysm clotted, pulsation stopped, and there was intense right-sided headache for several days, becoming less before her discharge. No paralyses.

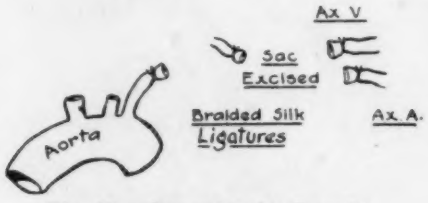

Fig. 56.—Operation in Case 56.

Result.—Well, October 7.

November 10, headache nearly gone. Swelling present and hard.

Fall of 1921, entirely well, swelling gone.

May 29, 1922, the patient wrote that she could still feel a little fulness in her throat, which, however, does not pulsate. The throat has not been examined by a physician for more than a year.

7. FIVE CASES OF SUBCLAVIAN ANEURYSM

CASE 56.—*History.*—April 30, 1892; 52; man; colored; married; farmer. Aneurysm of the left subclavio-axillary artery of nine months' duration. Etiology unknown.

Symptoms and Physical Signs.—No swelling of the arm. No pulse in the arm. Size, 13 cm. in diameter. The circulation in the arm was good. No record was made of the blood pressure or nerve involvement. The heart was normal. The aneurysm became clotted three weeks before operation and its pulsation much reduced.

Operation.—May 10. Dr. W. S. Halsted. Ligation of the first portion of the left subclavian artery. Excision of the aneurysm. Ligation of the axillary vessels. Clavicle removed.

Postoperative Course.—The blood clot organized without breaking down.

Result.—Well, August 1. No further history.

CASE 57.—*History.*—Oct. 17, 1905; 50; woman; white; widowed; housewife. Aneurysm of the right subclavian artery of six years' duration. No history of syphilis.

Symptoms and Physical Signs.—The aneurysm was wired in December, 1904, by Dr. McDonald. The heart was normal. There was tingling in the fingers, but no nerve paralysis. The radial pulse was a little delayed. The tumor was 7 by 8 cm.

Operation.—November 17. Dr. W. S. Halsted. Partial ligation of the innominate, artery with No. 33 aluminum band 1.5 cm. wide, wrapped twice around the artery and held in place by a heavy black silk ligature. Two thirds of the clavicle and part of the first rib resected.

Second Operation.—Jan. 12, 1906. Dr. W. S. Halsted. Ligation of the subclavian artery for aneurysm. Pulsation in the aneurysm persisted after ligation on both sides of the aneurysm.

Postoperative Course.—The pulsation was reduced somewhat by the application of the band, but the size was unchanged. January 12, the blood pressure in the right arm was 100, in the left, 102. There was no pulse in the tumor at the first dressing after the second operation.

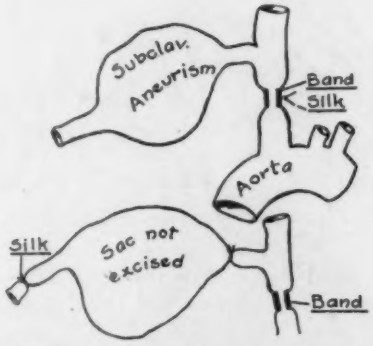

Fig. 57.—First and second operation in Case 57.

Result.—Well, February 10. On admission, March 31, 1921, the aneurysm was gone; the function of the arm was not impaired. There was a beautiful dilatation of the common carotid distal to the band.

CASE 58.—*History.*—March 7, 1909; 48; woman; white; married; housewife. Aneurysm of the right subclavian artery of two or three months' duration. No history of syphilis. Arteriosclerosis.

Symptoms and Physical Signs.—Slight numbness in the right arm. Swelling in the neck. Headache. Marked arteriosclerosis. Radial pulse well felt. Heart 11 cm. to the left. The blood pressure was 150 in the right, 145 in the left arm. Bruit present. Swelling not very large.

First Operation.—March 12. Dr. W. S. Halsted. Application of an aluminum band to the right subclavian artery. Partial occlusion.

Second Operation,—March 31. Dr. W. S. Halsted. Exploration of the subclavian and carotid arteries. No signs of aneurysm found. Weak pulse in the subclavian in its third portion. Nothing done to the vessels.

Postoperative Course.—The radial pulse was retarded after the first operation, but was otherwise good. The bruit disappeared. Slight return of the

pulsation was noted in the aneurysm, March 26. No notes on the surface temperature. Operation advised on the vessels distally. After the second operation the pulse in the aneurysm was gone. The radial pulse was less retarded. Abnormal pulsation noted below the left clavicle, but no thrill or bruit. April 14, 1909, the blood pressure in the right arm was 128, in the left arm, 138. No thrill or bruit on the right.

Result.—Well, April 14. No further history.

I doubt if this was a true aneurysm. It was probably a calcified tortuous subclavian artery on the right, less marked on the left.

CASE 59.—*History.*—Oct. 18, 1912; 47; man; colored; single; singer. Aneurysm of the right subclavian artery of three and three-fourth years' and of eleven days' duration. Syphilis for twenty-five years; gonorrhea twice; Wassermann reaction positive.

Symptoms and Physical Signs.—Mayo ligated the first portion of the subclavian artery in June, 1909. The patient remained well until eleven days before admission, when he discovered the swelling again. The heart extended 11 cm. to the left. The sounds were normal. There was a large swelling behind the inner end of the clavicle and sternoclavicular joint. It measured 13 by 8.5 cm. No pulse in the right axillary, brachial or radial arteries. Surface temperature

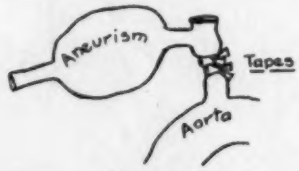

Fig. 58.—Operation in Case 59.

of the right arm and hand lower than the left. The circulation was good. Function and sensation normal. Ptosis and small pupil. The temporal pulse was normal.

Operation.—November 7. Dr. W. S. Halsted. Ligation of the right innominate artery for subclavian aneurysm. A very faint pulsation in the aneurysm had returned by the time the wound was closed.

Postoperative Course.—The aneurysm became smaller, measuring 5.5 by 4.1 cm. on discharge. A small pulsation, however, persisted. No circulatory embarrassment of the hand. Surface temperatures about the same.

Result.—Improved, December 24. No further history.

Dr. Halsted thought that this aneurysm may have been where Mayo ligated and that the first aneurysm was in the third portion of the subclavian artery. This aneurysm extended almost to the junction of the subclavian with the innominate artery.

CASE 60.[3]—*History.*—April 22, 1918; 29; man; colored; single; laborer. Aneurysm of the left subclavian artery of one year's duration. Syphilis for four years. Pistol shot injury four years before. Wassermann reaction positive.

Symptoms and Physical Signs.—Rapid increase in size during the last month. Paralysis of the arm. Marked sensory changes. Pain. Enormous swelling in

3. This case was reported in full by Halsted, W. S.: Bull. Johns Hopkins Hosp. **31**:219 (July) 1920.

the neck. Pupils equal. Heart normal. Left arm very cold. No pulse in the wrist.

Operation.—April 26. Dr. W. S. Halsted. Ligation of the left common carotid and left subclavian arteries for subclavian aneurysm.

Postoperative Course.—The circulation in the arm remained sufficient. Rather prompt return of a very variable temporal pulse. No return of the pulse in the hand. No cerebral changes. Slight arthritis of the right knee. No return of pulsation in the aneurysm. The aneurysm became very hard at first; later it became tense. The arm was swollen for several days. No comment on the surface temperature. Syphilitic treatment.

Result.—Well, August 12.

March 15, 1919, aneurysm dead, size of an orange. Paralysis of the arm unimproved. Slight ptosis. Temporal pulse one-half the volume of the right. No pulse in the arm. Brain all right.

March 5, 1920, return of pulsation and increase in size of aneurysm. The Wassermann reaction was less strongly positive at this time than on the previous admission.

Fig. 59.—First operation in Case 60: ligation of the left common carotid and subclavian arteries near their origin.

Fig. 60.—Second operation in Case 60 two years after the first: excision of the subclavian aneurysm.

Second Operation.—April 12, 1920. Dr. W. S. Halsted. Excision of subclavian aneurysm.

Postoperative Course.—Slight accumulation of fluid. No infection. Interesting temperature changes.

Result.—Well, May 29, 1920.

8. TWO CASES OF AXILLARY ANEURYSM

Case 61.—*History.*—Nov. 26, 1916; 21; man; colored; married; porter. Traumatic aneurysm of the right axillary artery of eighteen days' duration. Pistol shot. Syphilis for one year. Gonorrheal infection.

Symptoms and Physical Signs.—Heart normal. Brachial plexus palsy. Pulse in the right wrist "not very good." Motor palsy of the arm. Sensation retained.

Operation.—November 29. Dr. G. J. Heuer and Dr. W. E. Dandy. Excision of a segment of the axillary artery for false aneurysm. Suture of divided nerves. Vein uninjured.

Postoperative Course.—Marked return of function and sensation. December 6, the radial pulse was definitely felt and counted. No comment on surface temperature was made. No definite impairment of circulation.

Result.—Improved, December 7. No further history.

A false aneurysm the size of a walnut due to a tangential injury of the artery was pressing against the overstretched nerves. The aneurysm was just behind the pectoralis minor muscle.

Case 62.—*History.*—June 27, 1918; 23; woman; colored; married; housework. Traumatic aneurysm of the left axillary artery of four months' duration. Pistol shot. Wassermann reaction negative.

Symptoms and Physical Signs.—Severe pain and drawing of the arm. Paralysis developed in the last two weeks. No paralysis at first. Radial pulse retarded and very weak. Heart normal. Musculocutaneous, median, radial and ulnar nerves paralyzed. Blood pressure estimation not possible in the left arm; right 129/82. Thrill and bruit. Marked dilatation of the arch of the aorta. Aneurysm filled the axillary space and bulged the pectoral.

Operation.—July 1. Dr. M. R. Reid. Ligation of the third portion of the left subclavian artery for axillary aneurysm. Clavicle resected.

Postoperative Course.—Circulation not embarrassed. Radial pulse did not return. Function improved. Surface temperature not stated.

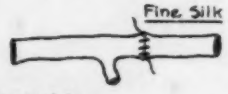

Fig. 61.—Excision of the aneurysm and end-to-end anastomosis of the artery in Case 63.

Result.—Well, July 17, and six months later. Aneurysm gone. Function largely restored.

The notes are suggestive of an arteriovenous fistula; I did not so regard the case at the time, however.

9. ONE CASE OF ANEURYSM OF THE BRACHIAL ARTERY

Case 63.—*History.*—Sept. 2, 1920; 24; man; white; single; farmer. Aneurysm of the right brachial artery of nine months' duration due to a pistol shot. No history of syphilis given; Wassermann reaction negative.

Symptoms and Physical Signs.—Heart normal. No infection at the time of injury. Swelling 6 cm. in diameter. Tumor just above the internal condyle. Radial pulse weaker by one-third than the left. Right hand colder than the left. Median nerve partly paralyzed. "With the hand pendant the cyanosis corresponds to the distribution of the median nerve" (Holman). Weakness of flexion in the thumb, index and middle fingers. Blood pressure, right arm 142/86; left 134/84.

Operation.—September 8. Dr. M. R. Reid. Excision of brachial aneurysm. End-to-end anastomosis of the brachial artery. Aneurysm the size of an egg excised. Median nerve compressed by the aneurysm. Radial pulse better after the operation than before.

Postoperative Course.—On the night of operation the hand was red and warm, and remained redder than the left for several days. At times this

hand, especially the wrist, felt warmer than the left. Sensation and function improved. Radial pulses equal on discharge. Blood pressure 132/80 in both arms.

Result.—Well, September 20. No further history.

Flexion of the arm made the anastomosis possible. At the time of the patient's discharge from the hospital extension of the arm 30 degrees beyond a right angle made the pulse weaken and disappear.

10. TWO CASES OF ANEURYSM OF THE VERTEBRAL ARTERY

CASE 64.—*History.*—Aug. 6, 1917; 20; man; white; single; laborer. Traumatic aneurysm of the left vertebral artery of three months' duration, due to a stab in the neck. Wassermann reaction negative.

Symptoms and Physical Signs.—Profuse bleeding after injury. Primary healing. Small tumor, pulsating, increasing in size. Heart normal. Noise in the head, bruit and thrill made us make a diagnosis of arteriovenous aneurysm. No paralysis of hands. Origin in the vertebral artery not suspected.

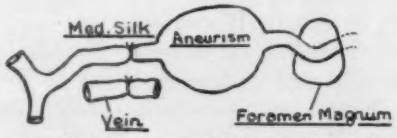

Fig. 62.—First operation in Case 64.

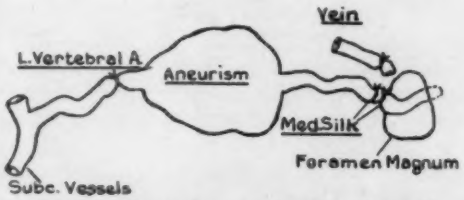

Fig. 63.—Second operation in Case 64.

Operation.—August 11. Dr. W. E. Dandy. Ligation of the left vertebral artery for vertebral aneurysm. Long time spent in determining the origin of the aneurysm.

Postoperative Course.—Tumor unchanged. Rapid development of paralysis of left arm (extensor muscles mainly). Unequal pupils. Slight decrease in pulsation.

Result.—Not improved, August 25.

The patient returned October 6, with these symptoms: Tumor about the same; ptosis; unequal pupils, and palsy of both arms.

Second Operation.—November 8. Dr. W. E. Dandy. Ligation of left vertebral artery distal to aneurysm of this vessel. Accompanying veins also ligated.

Postoperative Course.—Paralysis persisted. Aneurysm became dead. Ptosis persisted.

Result.—Well, except for paralysis of arms, Feb. 23, 1918.

April 12, practically no improvement in paralysis of arms. Aneurysm gone except for a small swelling the size of an almond, hard and nonpulsile. No later observations.

What proof have we that this might not have been an arteriovenous fistula?

CASE 65.—*History.*—July 25, 1921; 52; man; white; married. Aneurysm of the left vertebral artery of fifteen years' duration and longer. No history of syphilis obtained; Wassermann reaction negative.

Symptoms and Physical Signs.—Vertigo, dizziness, headaches, suggesting a cerebellar lesion. Heart normal. Blood pressure 120/70.

First Operation.—July 29. Dr. W. E. Dandy. Cerebellar exploration revealing an aneurysm of the left vertebral artery and arteriosclerosis of the right. Nothing done.

Second Operation.—August 28. Dr. W. E. Dandy. Ligation of the left vertebral artery just below the atlas.

Postoperative Course and Result.—Death three days later, August 31. Temperature rose to 107. Stupor.

11. ONE CASE OF ANEURYSM OF THE TEMPORAL ARTERY

CASE 66.—*History.*—March 13, 1896; 57; man; white; widower; agent. Aneurysm of the right temporal artery of five years' duration. Syphilis twelve years before admission with secondary eruption. No information as to treatment.

Symptoms and Physical Signs.—Aneurysm size of a small orange. Heart negative. Right hemiplegia two years before with slight residuum. Some syphilitic signs on shin, and scars.

Fig. 64.—Operation in Case 65.

Operation.—March 20. Dr. J. C. Bloodgood. Ligation and division of the right common carotid artery above the omohyoid.

Postoperative Course.—No pulsation immediately after operation; sac was much smaller. At first dressing, April 3, 1896, sac had refilled. As large on discharge as before operation, but no pulsation.

Result.—Improved, April 15. No further history.

Why did he not ligate the external carotid? Operative note says that he would have ligated the internal carotid if it had not been sclerotic.

12. THREE CASES OF ANEURYSM OF THE RADIAL ARTERY

CASE 67.—*History.*—March 24, 1909; 19; man; white; married; laborer. Traumatic aneurysm of the right radial artery of six months' duration. No history of syphilis. Stabbed with a knife.

Symptoms and Physical Signs.—Just below the elbow, on the flexor surface of the forearm, was a tumor 7.5 cm. in diameter. There were no sensory or motor disturbances. The temperature of the two hands was the same. The right radial pulse was weaker than the left. The ulnar artery was not felt. The heart measured 11.5 cm. to the left. The blood pressure was 93 in both arms.

Operation.—April 3. Dr. J. M. T. Finney. Excision of the radial aneurysm at the head of the radius.

Postoperative Course.—The ring finger and little finger were cold for two days. The others were as warm as the left hand. The circulation was good in all fingers judging by the color. The pulse did not return at the wrist. No mention of the hand being warmer than the left.

Result.—Well, April 9. No further history.

CASE 68.—*History.*—April 25, 1911; 67; man; white; married; tobacco dealer. Aneurysm, of the second branch of the right radial artery of two and one-half years' duration. Gonorrheal infection. No information as to syphilitic infection.

Symptoms and Physical Signs.—Swelling the size of a small hen's egg on the back of the hand at the junction of the first metacarpal and carpal bones. No injury. Heart normal. No paralysis.

Operation.—April 26. Dr. J. M. T. Finney. Excision of aneurysm. Ligation of the radial artery.

Postoperative Course.—Healing by first intention. No further comment.

Result.—Well, April 29.

CASE 69.—*History.*—Jan. 30, 1921; 19; man; colored; single; laborer. Traumatic aneurysm of the left radial artery of four days' duration. Stab wound. Syphilis for three years.

Symptoms and Physical Signs.—A large hematoma, pulsating and connecting with a lacerated artery, situated just above the wrist, where one ordinarily feels for the pulse. Heart normal.

First Operation.—January 31. Dr. M. R. Reid. Ligation of the left radial artery for infected pulsating hematoma.

Second Operation.—February 3. Dr. M. R. Reid. Incision and drainage of infected forearm.

Postoperative Course.—No circulatory disturbances followed the first operation. Infection traveled up the arm, necessitating further opening and drainage, which was treated by surgical solution of chlorinated soda (Dakin's solution) with prompt healing.

Result.—Well, February 14.

In this case the artery should have been tied when the patient came into the accident room. Only the wound was sutured.

13. THREE CASES OF ANEURYSM OF THE ULNAR ARTERY

CASE 70.—*History.*—Dec. 16, 1902; 23; man; white; single; engineer. False sac and blood clot of the right ulnar artery, of eleven days' duration caused by a cut with glass.

Symptoms and Physical Signs.—Hematoma of the forearm, connecting with a divided artery and leading to frequent severe hemorrhages.

Operation.—December 18. Dr. M. B. Tinker. Ligation of the ulnar artery at the site of an incised wound.

Postoperative Course.—Discharged after six days. Wound granulating and healthy.

Result.—Well, December 23. No further history.

CASE 71.—*History.*—Nov. 5, 1894; 13; white; school boy. Traumatic aneurysm of the right ulnar artery in the palm of nine weeks' duration.

Symptoms and Physical Signs.—Stuck in the hand by a pocket knife blade. Healed in four weeks; then broke open and bled profusely. An open wound filled with a large pulsating clot bleeding readily. Heart and lungs normal.

Operation.—November 6. Dr. W. S. Halsted. Ligation of the ulnar artery and branches of the palmar arch entering the aneurysm. Excision of the sac. Thorough irrigation with mercuric chlorid, 1:1,000.

Postoperative Course.—Healing by first intention.

Result.—Well, November 12. No further history.

CASE 72.—*History.*—May 26, 1913; 19; man; white; single; orderly. Traumatic aneurysm of the right ulnar artery of ten days' duration due to a stab wound with scissors. No history of syphilis.

Symptoms and Physical Signs.—Swelling, ecchymosis and pulsation of the middle forearm. No infection. Great pain. Numbness of the fingers and loss of function. Bruit audible. Heart normal.

Operation.—May 27. Dr. R. D. McClure. Ligation of the right ulnar artery for traumatic aneurysm. Nerve uninjured. Artery found completely divided. Central end beating into the clot; distal end thrombosed.

Postoperative Course.—Prompt relief of pain and return of function. No comment on surface temperatures.

Result.—Well, May 31. A pulsating hematoma.

14. ONE CASE OF ANEURYSM OF THE POSTERIOR TIBIAL ARTERY

CASE 73.—*History.*—July 27, 1921; 6½ years; girl; white. Traumatic aneurysm of the left posterior tibial artery of five weeks' duration due to an incised wound.

Symptoms and Physical Signs.—Two severe hemorrhages from the wound following a little injury. Just behind the malleolus was a pulsating tumor the size of an almond.

Operation.—July 28. Dr. E. F. Holman. Ligation of the posterior tibial artery for traumatic false aneurysm.

Postoperative Course.—Function and sensation good.

Result.—Well, August 1.

Examination, April 22, 1922, by Dr. E. F. Holman, revealed the appearance of both feet to be identical. No difference subjectively in cold weather. Motion of toes, of ankle, unimpaired. Able to walk equally well on both feet. No anesthesia, hyperesthesia or paresthesia. No numbness. Posterior tibial and dorsalis pedis pulses palpable on the right but not palpable on the left (the involved side).

15. THREE CASES OF ANEURYSM OF THE DORSALIS PEDIS ARTERY

CASE 74.—*History.*—Dec. 4, 1892; 35; man; white; single; farmer. Aneurysm of the left dorsalis pedis artery of two months' duration, possibly of traumatic origin. Syphilis six years before admission, treated for two or three weeks. Secondary eruption. Alcoholic. Two ankle sprains a month before onset.

Symptoms and Physical Signs.—Tumor the size of an egg on anterior part of ankle. Circulation in foot and nerves undisturbed. Heart normal.

Operation.—December 8. Dr. J. M. T. Finney. Ligation of the arteries proximally and distally. Excision of aneurysm. Aneurysm extended into ankle joint, eroding astragalus.

Postoperative Course.—Function good.

Result.—Well, Jan. 28, 1893. No further history.

The aneurysm was partially filled with old and recent blood clot. It continued to beat until all accessory branches were tied. The sprains of the ankle were probably responsible for the location of the aneurysm.

CASE 75.—*History.*—Dec. 8, 1894; 40; man; colored; married; cook. Aneurysms of the right common carotid artery of thirty years' duration, and of the dorsalis pedis on the left of nine months' duration. Syphilis twenty years before admission. No history of treatment.

Symptoms and Physical Signs.—Heart slightly enlarged. Apex in sixth interspace 12.5 cm. from midmammillary line. Neck tumor the size of a walnut. Foot tumor the size of a shelled walnut. Condition of pulse and nerves not mentioned. Aneurysm of foot involved a branch of dorsalis pedis artery on left side of instep.

Operation.—December 8. Dr. W. S. Halsted. Excision of aneurysm of the foot. Neck not operated on.

Postoperative Course.—Healing by first intention.

Result.—Well, December 24. From Sept. 18 to 24, 1895, the patient was in the hospital on account of swelling of the foot. This subsided when the foot was elevated. No further record.

CASE 76.—*History.*—April 20, 1912; 26; man; colored; single; stevedore. Aneurysm of the dorsalis pedis artery of the left foot of two months' duration. Syphilis with secondary manifestations; Wassermann reaction positive. Gonorrheal infection.

Symptoms and Physical Signs.—Syphilitic treatment (irregularly) for a year before admission. Heart slightly enlarged. Sounds clear. Pain in the tumor which was 3.5 cm. in diameter.

Operation.—April 30. Dr. W. S. Halsted. Complete excision of aneurysm of dorsalis pedis artery, left foot.

Postoperative Course.—The patient given syphilitic treatment and told to continue it.

Result.—Well, May 19. No further history.

16. TWENTY-SIX CASES OF ABNORMAL ARTERIOVENOUS COMMUNICATIONS (ARTERIOVENOUS ANEURYSM, CIRSOID ANEURYSM, ANEURYSM BY ANASTOMOSIS, PULSATING ANGIOMA, ETC.)

CASE 77.—*History.*—Dec. 26, 1904; 23; man; white; married; teacher. Arteriovenous aneurysm (pulsating angioma, aneurysm varix) of ten years' duration caused by a baseball injury.

Symptoms and Physical Signs.—Swelling began in the middle finger and extended to the palm of the hand, thenar and hypothenar eminences. Heart normal.

Operation.—December 26. Dr. J. M. T. Finney. Ligation of the radial artery. Partial excision of the vessels of the palm of the hand for probable arteriovenous aneurysm.

Postoperative Course.—Healing by first intention.

Result.—Improved, December 31.

Playing baseball was possibly the cause. The size of the radial artery was not noted. The fistulas were not found.

April 29, 1922, a letter from the patient stated that he was well.

CASE 78.—*History.*—Aug. 5, 1907; 23; woman; white; single; seamstress. Pulsating angioma of the left lower eyelid of eighteen years' duration, of congenital origin.

Symptoms and Physical Signs.—Heart normal. A small pulsating angioma involving the external two thirds of the lower lid.

Operation.—August 6. Dr. R. T. Miller. Excision of cirsoid aneurysm of the left lower lid. Communicating branch was from the ophthalmic artery.

Postoperative Course.—Healing by first intention.

Result.—Well, August 7. No further history.

A small flap was turned up and the vessels dissected out. The feeder seemed to come from the ophthalmic artery.

CASE 79.—*History.*—Feb. 12, 1908; 55; man; white; married. Pulsating angioma of the palm of the right hand of from fifteen to twenty-five years' duration, caused by a blow from an axe handle (?).

Symptoms and Physical Signs.—Lesion involved the palm of the hand, the middle finger and a little of the back of the hand. Thrill, bruit, etc. Network of pulsating veins. Heart normal. Proximal dilatation not noted.

Operation.—February 13. Dr. R. H. Follis. Excision of arteriovenous aneurysm, palm of the right hand; amputation of the middle finger. No definite fistula found. All the veins pulsated.

Postoperative Course.—Veins on the dorsum of the hand continued to pulsate for several days and then apparently thrombosed.

Result.—Well, February 24.

No communication between arteries and veins was found in the specimen.

April 19, 1922 (letter), at times the hand felt a little numb; could use it perfectly; no evidence of the former condition.

CASE 80.—*History.*—Feb. 9, 1921; 19; man; colored; single; laborer. Pulsating angioma of the left forehead, midway between the eyebrow and the hair line, of three years' duration. No history of syphilis or gonorrheal infection. Wassermann reaction negative.

Symptoms and Physical Signs.—Duration just three years. When first noted it was the size of a pea. No injury. Gradual growth with pulsation and development of tortuous vessels on the forehead. No symptoms. Tumor half the size of a walnut. Temporal artery dilated. Heart normal. No thrill or bruit.

Operation.—February 16. Dr. G. J. Heuer. Excision of pulsating hemangioma of the scalp. Very vascular.

Postoperative Course.—Healing by first intention.

Result.—Well, February 22.

CASE 81.—*History.*—Feb. 8, 1922; 19; man; white; single; clerk. Pulsating angioma of the cerebral sylvian vessels on the right side of congenital origin, and with symptoms for seven years. No history of syphilis or gonorrhea.

Symptoms and Physical Signs.—Jacksonian epilepsy of the left side. Heart normal. No thrill or bruit.

Operation.—February 11. Dr. W. E. Dandy. Exploratory craniotomy. Ligation and excision of an intracortical pulsating angioma—arteriovenous fistula. Ligation of the common and internal carotid vessels.

Postoperative Course.—Death from hemorrhage. The sylvian vessels near the tip of the temporal lobe were ligated, but the thrill and bruit continued.

When they were ligated near the longitudinal sinus, the brain swelled and ruptured, producing an uncontrollable hemorrhage. Carotid vessels in the neck ligated.

Result.—Death, February 11.

A congenital pulsating angioma within the cortex and on its surface along the parietal region. Veins filled with arterial blood and pulsating. Thrill and bruit. A most remarkable picture. Veins the size of one's little finger.

CASE 82.—*History.*—Jan. 27, 1922; 9; school boy; white. Pulsating angioma of the right side of the head (of congenital origin?). Hematoma at the time of birth. Wassermann reaction negative.

Symptoms and Physical Signs.—Small tumor. Thrill and bruit. Dilated vessels running into the tumor. Large tortuous temporal vessels. Heart normal. Main tumor the size of the thumb and about as long. Gradual increase. Skin thin and bluish in a few places.

Operation.—February 4. Dr. E. F. Holman. Excision of pulsating nevus of the scalp. Pedicle clamp used.

Postoperative Course.—Thrill and bruit gone. Healing by first intention.

Result.—Well, February 12.

April 26, no dilated vessels could be seen in the scalp. No evidence of any further arteriovenous communications.

CASE 83.—*History.*—May 21, 1897; 37; man; white; single; laborer. Arteriovenous aneurysm of the left popliteal artery of traumatic origin and eight years' duration. Syphilis for seventeen years.

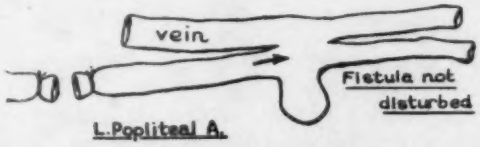

Fig. 65.—Operation in Case 83: ligation of the artery proximal to a popliteal arteriovenous fistula. Gangrene of the leg resulted.

Symptoms and Physical Signs.—Shot eight years before admission; primary healing after profuse bleeding. Thrill and bruit. Swelling of the leg for four or five years. Pain over the heart. Heart enlarged; forcible murmur at the apex.

First Operation.—June 11. Dr. W. S. Halsted. Ligation of the femoral artery in Hunter's canal.

Postoperative Course.—Gangrene set in immediately, with demarcation at the junction of the upper and middle thirds of the leg. Gas bacillus infection.

Second Operation.—June 21. Dr. J. C. Bloodgood. Amputation of the leg at the lower third of the thigh.

Third Operation.—August 14. Dr. Harvey Cushing. Amputation of the stump.

Postoperative Course.—After the amputation above the fistula, bath treatment was given; several abscesses developed in the stump.

Result.—Well, with the leg amputated, October 3. No further history.

Artery dilated proximally. The size of the femoral artery was not mentioned in the history, but the old specimen in the laboratory showed the very definite proximal dilatation of the artery.

CASE 84.—*History.*—Jan. 22, 1901; 37; man; white; widower; farmer. Traumatic arteriovenous aneurysm of the femoral vessels in Hunter's canal in the left leg, of two and one-half months' duration. No history of syphilis; gonorrheal infection three years before admission.

Symptoms and Physical Signs.—Shot accidentally by a pistol, 8 inches (20.3 cm.) above the knee. Wound of exit midway between the knee and ankle became infected; it opened in two places six weeks later and continued to discharge. Entrance wound healed. Heart normal. Aneurysm, 12 by 9 cm., above the left knee in Hunter's canal, apparently not infected. Three sinuses below the knee. Considerable bleeding from the lower sinuses at the time of injury. Hematoma and infection afterward. "Definite thrill felt in popliteal space" (Mitchell). Foot drop.

First Operation.—January 29. Dr. W. S. Halsted. Ligation of the left femoral artery for traumatic aneurysm in Hunter's canal. Sinuses below the knee curetted and packed with iodoform gauze.

Second Operation.—March 2. Dr. W. S. Halsted. Exploration of femoral aneurysm. Incision of sac. Ligation of popliteal artery. Wounds packed with gauze.

Third Operation.—March 15. Dr. W. S. Halsted. Amputation of the thigh. Partial closure and drainage.

Postoperative Course.—The cause of the second operation is not stated, probably owing to continued pulsation of the tumor. After ligation of the popliteal artery, the sac had to be packed to control the hemorrhage; repacked later in the ward on account of hemorrhage. Infection of the foot set in with gangrene, and the leg was amputated.

Result.—Well, April 26.

May 16, 1922, the patient wrote that he was quite well and working hard on the farm. No other aneurysms had appeared.

This case, included in the records of the Johns Hopkins Hospital as a false arterial aneurysm, was an arteriovenous aneurysm, as was demonstrated by a study of the pathologic specimen.

CASE 85.—*History.*—Nov. 26, 1901; 19; man; white; single; farmer. Traumatic arteriovenous aneurysm of the left femoral vessels in Hunter's canal of three months' duration.

Symptoms and Physical Signs.—Profuse hemorrhage at the time of injury. In bed for three weeks. Rapid swelling with pulsation and loud bruit. Thrill not noted. Heart normal. Swelling 8 cm. in diameter. No pulse in foot. Condition of nerves not noted.

Operation.—December 6. Dr. W. S. Halsted. Ligation of the femoral artery. Suture of femoral vein. Partial excision of sac. Protective and iodoform drain to point of suture of the vein. Both vessels small.

The knife had gone through both walls of the artery and one wall of the vein, making a fistula as well as a false arterial aneurysm.

Result.—Well, December 31.

Discharged without note about the circulation in the foot or about the nerves. Pulse in the foot not noted. This was evidently an arteriovenous fistula and a large false aneurysm. Both vessels were very small. The operator tried to restore both lumens. This procedure occluded the artery, and he therefore excised it. The vein may have been occluded by sutures; he was not sure.

The patient was readmitted, Jan. 5, 1906, with the following symptoms: Weakness in the left leg. Gave out quickly with exercise, sometimes in just a few hours; very noticeable in the last six weeks; somewhat noticebale, however, since operation. The circumference of the right calf equaled that of the left. The circumference of the left thigh (middle) was 1.5 cm. smaller than that of the right. There was a distinct pulse behind the internal malleolus; not quite so strong on the left as on the right. Hard to find any pulse on the dorsum of either foot. Blood pressures in the legs: left, 65, 68 and 70; right, 100, 105, 105 and 103. The diagnosis was intermittent claudication.

Dr. H. M. Thomas, after a careful electric and neurologic examination, stated: "I find no neurologic condition and I believe the condition to be due to faulty circulation in the leg and would suggest moderate rest, massage and faradic stimulation."

The patient was discharged without treatment, January 9.

Examination, May 17, 1922, by Dr. Halsted, showed the patient in excellent health. Complained only of intermittent claudication. Could walk only about six blocks without resting for a few moments, then could proceed for another six blocks, and so on indefinitely, apparently. Venous circulation seemed to be perfect. No swelling of the leg.

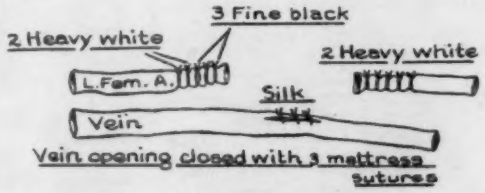

Fig. 66.—Excision of artery in Case 85. The vein was probably restored, a procedure now condemned. Silk ligatures were used.

Case 86.—*History.*—May 5, 1905; 28; man; white; single; carpenter. Arteriovenous aneurysm of the right intracranial vessels of three years' duration, following fracture of the base of the skull.

Symptoms and Physical Signs.—Exophthalmos with visible pulsation of the eye. Diplopia. Injected conjunctiva. Heart normal. Bruit and thrill. Fundus normal.

Operation.—May 15. Dr. Harvey Cushing. Ligation of the internal carotid artery.

Postoperative Course.—Healing by first intention.

Result.—Improved, May 26. Internal jugular vein pulsated. Size of the artery not noted. Eventually well after eight years.

Case 87.—*History.*—Aug. 6, 1905; 31; man; white; married; farmer. Traumatic arteriovenous aneurysm between the left occipital artery and vein, following a puncture wound and bruises. Duration seven years.

Symptoms and Physical Signs.—Swelling noted two months after injury. Buzzing for the last two years. Occipital artery ligated April 15; slight improvement. Tumor 5 by 2.5 cm. Thrill and bruit. Heart—point of maximum impulse in midmammillary line, fifth interspace. Soft murmur at the apex.

Operation.—August 9. Dr. Harvey Cushing. Ligation of the external carotid. Excision of aneurysmal varix.

Postoperative Course.—Healing by first intention.

Result.—Well, August 25. No further history.

Specimen showed a small opening connecting the occipital artery and vein.

CASE 88.—*History.*—Feb. 9, 1911; 55; man; white; married; blacksmith. Arteriovenous aneurysm of the right femoral vessels of four months' duration, following injury by a piece of flying steel. No history of syphilis.

Symptoms and Physical Signs.—Point of injury four inches (10.1 cm.) below Poupart's ligament. Typical signs. Heart normal. Very large veins in the leg below the fistula. No edema. Pulse in the foot well felt, better even than in the other foot.

Operation.—February 17. Dr. W. S. Halsted. Application of a metallic band to the femoral vein for arteriovenous fistula.

Postoperative Course.—March 19, heart enlarged 12.5 cm. to the left; not to the right. Sounds clear. No hypertrophy of the right side of the heart. Venous pressure became equal in the two legs. No much change in the physical signs. Surface temperatures not noted.

Result.—Improved (?), March 29. Letter in 1918 stated that the condition was about the same. Small ulcer on the shin.

April 22, 1922, slight weakness of the leg. Large varicose veins. Ulcer healed. Working steadily (letter).

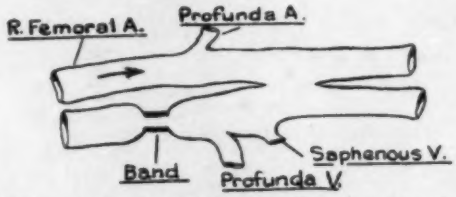

Fig. 67.—Application of a partially occluding metallic band to the femoral vein proximal to a fistula in Case 88.

CASE 89.[4]—*History.*—Nov. 3, 1911; 11; school girl; white. Congenital arteriovenous aneurysm of the right external carotid and external jugular. Wassermann reaction negative.

Symptoms and Physical Signs.—Swelling in front of and below the right ear. Buzzing noted three days after birth. Heart normal.

Operation.—November 15. Dr. W. S. Halsted. Excision of veins of the neck. Ligation of the external carotid artery for aneurysmal varix of the neck. Proximal artery large.

Postoperative Course.—Thrill disappeared. Slight bruit on discharge from the hospital.

Result.—Improved, December 12.

The patient again came under observation, May 15, 1918, at the age of 18. She was single and working in a paint factory. Congenital arteriovenous aneurysm of the right external carotid and external jugular. Wassermann reaction negative.

Symptoms and Physical Signs.—Gradual return of bruit, swelling and thrill. Very large common carotid artery.

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4. This case was fully reported and illustrated by Halsted, W. S.: Tr. Am. S. A., 1919.

Second Operation.—May 24, 1918. Dr. M. R. Reid. Partial excision of cirsoid aneurysm of the neck.

Postoperative Course.—A slight swelling the size of a cherry remained; no thrill; a bruit.

Result.—Improved, June 9.

Examination, March 14, 1922, by me showed the patient feeling well except for a little headache occasionally. General condition excellent. Condition seemed to have made some advance, shown especially in the angioma of the right side of the face. Fistula seemed to have increased in size. Thrill and bruit present. Right carotid artery about three times as large as the left. Heart seemed to be normal. The roentgen-ray report of the chest, March 14, revealed the heart and aorta normal in size; lungs clear.

CASE 90.—*History.*—July 7, 1913; 47; man; colored; married; laborer. Arteriovenous aneurysms of the left femoral vessels following a shot thirty years before admission and a kick in the groin two years before. Thrill and pulsation for two years. No history of syphilis. Wassermann reaction negative.

Symptoms and Physical Signs.—Surface temperature of the left leg below the middle of the thigh lower than in the right. No sensory changes. Pulse weaker in the left foot. Leg almost useless, toe drop, etc. Motor paralysis not thought due to peripheral nerves. Some little edema of the leg. Rapid tiring of the leg.

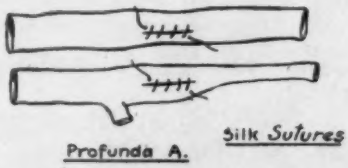

Fig. 68.—Restoration of artery and vein for femoral arteriovenous aneurysm in Case 90. Death was caused by pulmonary infarcts.

Operation.—July 15. Dr. G. J. Heuer. Lateral suture of the femoral artery and vein for arteriovenous fistula. Artery very large above fistula (size of index finger); small below (size of slate pencil). Marked calcification at the site of fistula.

Postoperative Course.—Circulation remained good. Motor paralysis remained about the same. Developed pneumonia, empyema and gangrene of the lung due to pulmonary infarcts. Rib resection, July 28.

Result.—Death, August 18.

CASE 91.—*History.*—Oct. 13, 1916; 48; man; colored; married; hostler. Arteriovenous aneurysm of the right femoral vessels in Hunter's canal. Penetrating wound low in the thigh. Duration about twenty-five years.

Symptoms and Physical Signs.—Large heart. Huge tortuous femoral artery from above Poupart's ligament to Hunter's canal, resembling in places a true aneurysm. Scar over the lower part of Hunter's canal. Here a thrill and bruit. Leg somewhat swollen; color blacker; small ulcer on the shin. Severe hemorrhage from the urethra thirty years before admission; twice from the ulcer, last time five years before. No history of injury that caused the fistula. Venous pressure right calf, 19.5; left calf, 7.

Operation.—October 31. Dr. W. S. Halsted. Operation for arteriovenous fistula over right side of Hunter's canal. Restoration of both vessels. Artery very large proximally.

Postoperative Course.—Patient developed small pulmonary infarcts. Good pulse at all times in the foot. Foot a little cold for twelve hours; after that it was as warm as the other foot. Venous pressures became the same. Swelling of the leg went down. Operated on for double hernia before leaving the hospital.

Result.—Well, Feb. 18, 1917.

April 14, 1922, leg amputated because of gangrene due to a large true aneurysm of the femoral artery in Scarpa's triangle. Following the amputation this aneurysm clotted and disappeared.

CASE 92.—*History.*—April 17, 1917; 48; man; white; married; farmer. Arteriovenous aneurysm of the right intracranial vessels, resulting from a blow on the head, Feb. 16, 1916.

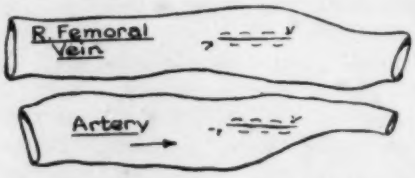

Fig. 69.—Restoration of the vessels for a large arteriovenous aneurysm in Hunter's canal in Case 91. Pulmonary infarcts occurred. Later the proximal artery developed a true aneurysm necessitating amputation.

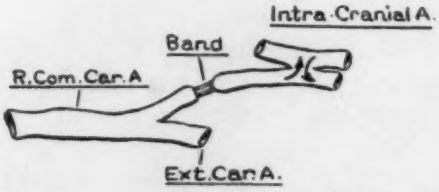

Fig. 70.—Occlusion of the internal carotid artery with a metallic band for pulsating exophthalmos in Case 92.

Symptoms and Physical Signs.—Roaring noise, double vision, disturbances of taste, smell, etc. Conjunctival hemorrhage. Poor vision in the right eye. Exophthalmos.

Operation.—April 19. Dr. G. J. Heuer. Application of an aluminum band to the right internal carotid artery; metal 7 mm. wide. Probably complete occlusion.

Postoperative Course.—Bruit disappeared; exophthalmos less. No cerebral disturbances.

Result.—Well, April 30.

A letter from the patient, Jan. 24, 1918, said that he was "blind in the right eye, not conscious of any noise; weak and dizzy, especially on stooping over."

August 4, examination showed the bruit still absent. Premature cataract in right eye. Nearly blind in right eye. Noises gone.

The patient stated in a letter written in April, 1922, that he worked on a farm. No noise in the head. Occasionally he had severe pains in the arms and legs followed by a sleep of an hour or longer. Eye was not prominent.

CASE 93.—*History.*—March 9, 1918; 55; man; colored; single; farmer. Arteriovenous aneurysm of the left intracranial vessels of two and one-half months' duration, resulting from a fall on the ice. Wassermann reaction negative.

Symptoms and Physical Signs.—Heart normal. No bleeding from the ears at any time. Roaring in the head. Pulsating exophthalmos. Eversion of the lids. Treated for gonorrheal infection of the eye.

Operation.—March 16. Dr. W. S. Halsted. Occlusion by metallic bands of the common and internal carotid arteries on the left side.

Postoperative Course.—No improvement for three days, then a sudden thrombosis with severe headache and a cessation of pulsation. After this a rapid cure. No cerebral disturbances. Good pulse in the temporal artery.

Result.—Well, April 25. No further history.

CASE 94.[5]—*History.*—Feb. 19, 1919; 19; man; white; single; jeweler's clerk. Congenital arteriovenous aneurysm of the right subclavian artery.

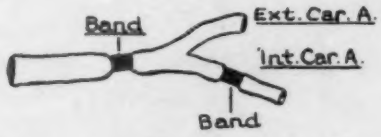

Fig. 71.—Ligations for pulsating exophthalmos in Case 93.

Symptoms and Physical Signs.—Symptoms for many years; noise in ear, etc. Swelling discovered only five years before admission. Heart normal. Enormous vessels in the right side of the neck overhanging the clavicle.

Operation.—February 25. Dr. M. R. Reid. Partial excision of aneurysm of the neck. Time, six hours. Did not get down to the fistula.

Postoperative Course.—Slight accumulation of fluid in the wound let out a few times.

Result.—Improved, March 31.

The patient was readmitted, May 17, 1920, following a gradual increase in the vessels, with thrill and bruit.

Second Operation.—May 28. Dr. M. R. Reid. Excision of arteriovenous fistula in the neck. Clavicle removed.

Postoperative Course.—Accumulation of fluid in the wound released on two occasions. Arm colder for two days; then upper arm was decidedly warmer than the opposite arm. Right forearm never became warmer than the left, but in a week became about as warm except for a cold area 10 or 12 cm. in diameter on the extensor surface just below the elbow. This was present on his discharge.

Result.—Well, June 21. Well, October, 1921.

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5. Reference should be made to the illustrations of Case 30 in Reid, M. R.: Abnormal Arteriovenous Communications, Acquired and Congenital, Arch. Surg. **10**:601 (March) 1925.

May 2, 1922, the patient wrote that so far as he could judge there were no observable circulatory effects in the arm. He could not raise the arm above his head because the collar bone was excised.

In March, 1924, the patient wrote that he was entirely well; had been granted a life insurance policy.

CASE 95.—*History.*—Jan. 3, 1920; 24; man; white; single; farmer. Arteriovenous aneurysm of the right popliteal vessels of six and one-half years' duration, following a pistol shot. Wassermann reaction negative.

Symptoms and Physical Signs.—Primary healing after the pistol shot. Bullet remained in the popliteal space. "Buzzing and swelling" began immediately. No cardiac symptoms. No venous dilatation outside the popliteal space. Leg not much swollen. Surface temperatures not noted. Pulse in the right foot weak. Heart normal. Blood pressure, right leg 176, left 160.

Operation.—January 10. Dr. W. E. Dandy. Aneurysmorrhaphy for arteriovenous fistula in the popliteal space. Removal of the bullet.

Postoperative Course.—Wound became infected; opened on the twelfth day and thoroughly treated with surgical solution of chlorinated soda (Dakin's

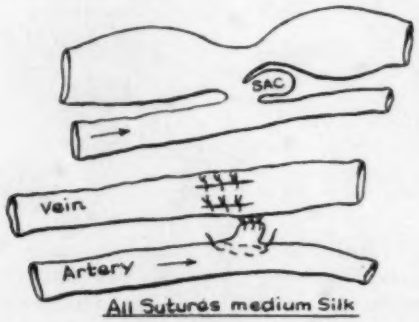

Fig. 72.—Restoration of the vessels for a popliteal arteriovenous aneurysm in Case 95.

solution). Several black silk stitches came away. On the sixth day the patient spat up blood and coughed, and the leg became swollen; possibly a small embolus. Good pulse in the dorsalis pedis on the evening of the operation but not felt in the posterior tibial. The next day it was easily felt in both and much better than before, and was well felt thereafter. Surface temperatures not commented on. Esmarch caused a partial motor and sensory paralysis; this cleared up before his discharge. Never any worry as to the circulation of the limb following operation.

Result.—Well, March 5. No further history.

CASE 96.[6]—*History.*—June 15, 1920; 34; woman; white; single; clerk. Arteriovenous aneurysm of the right external carotid and external jugular vessels of thirty-two years' duration, following a stab with the point of a scissors. Wassermann reaction negative.

Symptoms and Physical Signs.—Cardiac hypertrophy, with slight dilatation; mitral insufficiency. Thrill and bruit. Enormous dilatation of the vein. Common carotid large.

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6. Reid (Footnote 5, Case 14).

Operation.—June 22. Dr. M. R. Reid. Excision of arteriovenous fistula between the external carotid artery and external jugular vein. Artery very large proximal to the fistula.

Postoperative Course.—Prompt return of the temporal pulse. Weakness of the inframandibular branch of the facial nerve for two weeks. Heart became smaller. Bradycardia for several days after operation.

Result.—Well, July 10.

Was the bradycardia due to the removal of the effect of the fistula on the heart?

April, 1922, the patient wrote that there was no trace of any trouble in the neck, that she was entirely well.

CASE 97.—*History.*—May 20, 1921; 45; man; white; married; laborer. Arteriovenous aneurysm of the left intracranial vessels of eight weeks' duration, following a blow on the left jaw with an iron bar. Wassermann reaction negative.

Symptoms and Physical Signs.—Bulging of the left eye and buzzing in the left ear. Double vision. Ophthalmoplegia. Ptosis. Pupils equal. Left common carotid not large. Heart enlarged 12 cm. to the left. Hypertension.

Operation.—May 24. Dr. M. R. Reid. Occlusion of the common carotid by a metallic band; ligation of the external carotid artery with braided silk.

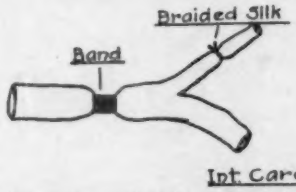

Fig. 73.—Ligations for pulsating exophthalmos in Case 97.

Postoperative Course.—No cerebral disturbances. Subsidence of exophthalmos. Gradual disappearance of the bruit. Residual palsy of the sixth nerve. Pulse disappeared proximal to the band on the common carotid.

Result.—Well, June 10. No further history.

CASE 98.[7]—*History.*—May 21, 1921; 36; woman; white; married; housewife. Congenital arteriovenous aneurysm of the anterior tibial vessels in the right leg, noted for thirty-one years.

Symptoms and Physical Signs.—Heart normal. Very large femoral artery. Right leg longer than the left. Pulsating veins, thrill and bruit.

First Operation.—May 25. Dr. M. R. Reid. Excision of the popliteal vein; ligation of the branches of the popliteal artery and ligation of the anterior tibial artery.

Second Operation.—June 2. Drs. G. J. Heuer and M. R. Reid. Amputation of the leg.

Postoperative Course.—The first operation did not stop the thrill and bruit. The femoral artery ruptured in the popliteal space, leading to a beginning gangrene, for which amputation was done. Following the amputation the proximal femoral vessel gradually became smaller.

Result.—Well, July 9, 1921, and March, 1925.

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7. Reid (Footnote 5, Case 31).

The popliteal artery was almost like a vein. It ruptured spontaneously opposite the point where the anterior tibial artery was ligated.

CASE 99.[8]—*History.*—May 12, 1921; 43; man; white; single; merchant. Arteriovenous aneurysm of the left femoral vessels of eight and one-half years' duration, following a pistol shot. Wassermann reaction negative.

Symptoms and Physical Signs.—Heart 14 cm. to the left; not large to the right. Swollen leg. Ulcer on the shin. Enormous dilated vessels about the hip (pulsating). Above the knee the surface temperature was higher, below the knee much lower than in the normal leg. No pulse in the foot. Circulation of the foot very unstable. Increased venous pressure.

Operation.—May 23. Dr. M. R. Reid. Excision of arteriovenous fistula of the femoral vessels of the left leg. The artery was very large proximal to the fistula, and larger than normal distally. Prompt return of the pulse in the distal end at the time of the operation.

Postoperative Course.—Mild *Staphylococcus albus* infection healing promptly after a few irrigations with surgical solution of chlorinated soda (Dakin's solution). Pulse noted in the foot on the day of operation and within two days it was as good as (almost better than) in the other foot. Surface temperature of the left leg markedly elevated for several days. Ulcer healed promptly.

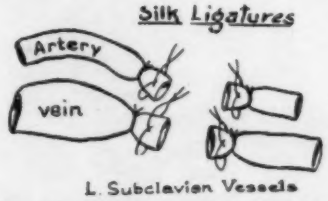

Fig. 74.—Operation in Case 100.

Result.—Well, July 25. Well, Christmas. April 21, 1922, the patient wrote that he was perfectly well; stood on his feet all day without inconvenience. The prompt return of a normal or better than normal pulse was striking, when none could be felt before.

CASE 100.—*History.*—Oct. 14, 1921; 35; man; white; married; laborer. Arteriovenous aneurysm of the left subclavian vessels of five months' duration, following a pistol shot. Wassermann reaction negative.

Symptoms and Physical Signs.—Swollen arm. Thrill and bruit. Enormous dilatation of the veins. Healing after injury by first intention. Surface temperature lower in the hand; equal at the elbow, and increased at the shoulder. Radial pulse one-third the volume of the right. Blood pressure, right 120/60; left 60. Heart normal. Venous pressure in left arm increased.

Operation.—October 26, Dr. M. R. Reid. Excision of the left subclavian arteriovenous fistula.

Postoperative Course.—Slight accumulation of serum. Rapid decrease in the swelling of the arm. Immediate improvement in the circulation. Radial pulse returned in twelve hours, and in two days was as strong as before operation. After that its volume was very variable. Oct. 28, 1921, temperature of the left hand 98.8, right 95. After a couple of weeks the two arms had the same temperature.

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8. Reid (Footnote 5, Case 17).

Result.—Well, December 7. April 29, 1922, the patient wrote that his left arm was almost as strong as the right. Could lift a 100 pound (45.4 kg.) bag of chop and shoulder it with ease.

From the weight of the arm on the chest following operation there was a mild ischemia in one area of the forearm. The artery proximal to the fistula was a little smaller than it was on the distal side.

CASE 101.[8]—*History.*—Oct. 26, 1921; 43; man; colored; married; laborer. Arteriovenous aneurysm of the right subclavian vessels of sixteen days' duration, following a pistol shot. No history of syphilis; Wassermann reaction negative.

Symptoms and Physical Signs.—No great edema at any time. Paralysis of the deltoid and partial paralysis of the flexors of the hand. Venous pressure, right arm 19; left 6. Blood pressure, right 95/60; left 115/75. Heart normal.

Operation.—November 3. Dr. M. R. Reid. Excision of arteriovenous fistula, right subclavian vessels, third portion. Artery definitely dilated proximal to the fistula.

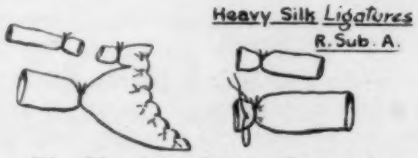

Fig. 75.—Operation in Case 101.

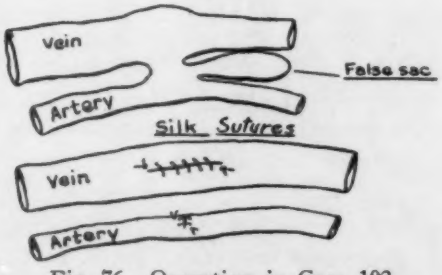

Fig. 76.—Operation in Case 102.

Postoperative Course.—Slight increase in the motor paralysis, but this was improving rapidly at the time of discharge. Pulse at times detectable in the radial. Circulation remained good. Electrical studies showed a lowered excitability, but no complete paralysis. For several days occasional twitchings of the fingers were noted. Surface temperatures felt to be the same.

Result.—Well, December 7. No further history.

Difficult case because so recent; hematoma was still in the muscle. Vessel walls opposite the fistula not well healed.

CASE 102.—*History.*—Feb. 28, 1922; 48; man; white; married; oil pumper. Arteriovenous aneurysm of the right femoral vessels in Hunter's canal of four weeks' duration, following a stab wound with a knife.

Symptoms and Physical Signs.—Thrill and bruit. False aneurysmal sac the size of a lemon. Heart normal. Pulse stronger in the left foot than in the right; some sensory disturbances.

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9. Reid (Footnote 5, Case 19).

Operation.—March 4. Dr. M. R. Reid. Separation of arteriovenous fistula. Restoration of the artery and vein.

Postoperative Course.—Pulse in the foot better immediately after operation than before. Next day it was stronger in the dorsalis pedis and posterior tibial than in the opposite foot. Foot and leg redder and hotter. A definite peripheral vasodilatation, peripheral arteries being larger and pulsating more vigorously. This peripheral dilatation persisted for three or four days, and then began to decrease, but was still noticeable at the end of ten days. Sensory disturbances unchanged. Temperature changes confirmed by thermometer.

Result.—Well, March 21. April 20, the patient wrote that there was no sign of weakness of the operated leg; that the pulse in the arteries of the ankle was better than the one on the opposite side.

On the second day after operation the pulse in the right dorsalis pedis artery was much stronger than in the left. Marked calcification about the artery made suturing difficult. A false sac was not disturbed after closing the openings of the vessels.

17. TWELVE CASES OF ANEURYSM OF THE ASCENDING ARCH OF THE AORTA TREATED BY WIRING OF THE SAC

CASE 103.—*History.*—Sept. 7, 1907; 46; man; white; married; mechanical engineer. Aneurysm of the ascending portion of the thoracic aorta of two years' duration. Syphilis for twelve years with secondary manifestations; well treated.

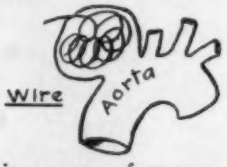

Fig. 77.—Method of treating cases of aneurysm of the ascending arch of the aorta.

Symptoms and Physical Signs.—Pain and cough. Pain extended down the arms. Heart not enlarged. Retromanubrial dulness 6 cm. to the right and 4 cm. to the left in the second interspace. Pupils small. Pulses equal and of small volume.

Operation.—September 13. Dr. J. M. T. Finney. Wiring of aortic aneurysm. Resection of the upper three quarters of the sternum together with the sternal end of the right clavicle and the costal cartilages of the first four ribs. Insertion of 11 feet of wire; galvanic current, 10 milliamperes; duration fifty minutes.

Postoperative Course.—Healing by first intention except for two drainage points which exuded serum for two weeks. Subjectively much improved. No good notes as to pulsation or size. Pain much relieved.

Result.—Well, October 7. A letter eight months after discharge said that the patient was entirely relieved, but did not comment on the aneurysm.

The patient returned, June 29, 1908, with recurrence of the swelling after a severe wrench in April, which was followed by a sensation of pressure. No pain.

Second Operation.—June 30. Dr. J. M. T. Finney. Aneurysm rewired. No incision. Twelve feet of wire introduced.

Postoperative Course.—After the second wiring there was relief and the swelling decreased in size. Slight oozing of blood from the needle puncture for several days.

Result.—Well, July 26.

April, 1922, letter returned; deceased.

The aneurysm reappeared to the right of the scar of the first operation.

CASE 104.—*History.*—Nov. 30, 1908; 43; man; white; single; custom inspector. Aneurysm of the ascending portion of the thoracic aorta of eight years' duration. Syphilis for nineteen years; gonorrheal infection twice.

Symptoms and Physical Signs.—Onset with pain. Treated with mercury and potassium iodid for several years. Pulsating tumor for four years or longer. Heart normal. Aneurysm presenting in the second interspace. Arteriosclerosis. Right radial pulse weaker than the left.

First Operation.—December 6. Dr. J. M. T. Finney. Wiring of a thoracic aneurysm with 11 feet of wire. Galvanic current of 10 milliamperes.

Second Operation.—March 7, 1909. Dr. J. M. T. Finney. Aneurysm rewired wilh 11 feet of wire. Galvanic current of not over 14 milliamperes.

Postoperative Course.—Great relief from pain. Aneurysmal pulsation became more punctate following the first operation. Only one attack of pain after the second operation. The aneurysm, however, was pulsating and could be felt in the left back on discharge.

Result.—Improved, April 19. No further history.

CASE 105.—*History.*—March 3, 1908; 39; man; white; married; farmer. Aneurysm of the first part of the thoracic aorta of thirteen months' duration. No history of syphilis; no information as to Wassermann reaction. Gonorrheal infection for nineteen years.

Symptoms and Physical Signs.—Onset of severe pain after a kick by a mule. Swelling noted for nine months. Heart 13 cm. to the left, 10 cm. to the right. Aneurysm pointed in the second right interspace.

Operation.—March 3. Dr. J. M. T. Finney. Wiring of aneurysm; 11 feet introduced; galvanic current.

Postoperative Course.—Patient not relieved; returned to the medical side of hospital for further treatment.

Result.—Transferred unimproved. Discharged from the medical side, improved, March 14. Died, August 18.

CASE 106.—*History.*—April 16, 1910; 48; man; colored; married; laborer. Aneurysm of the ascending aorta of four months' duration. Syphilis for many years; gonorrheal infection twice.

Symptoms and Physical Signs.—Severe pain. Mass pointing in the second right interspace; diameter 11 cm.

Operation.—May 6. Dr. J. M. T. Finney. Wiring of thoracic aneurysm with 11 feet of wire; galvanic current.

Postoperative Course.—Pulsation remained about the same. Pain was largely relieved.

Result.—Improved, May 24. Death, Nov. 2, 1911.

How he felt between his discharge from the hospital and death is not known.

CASE 107.—*History.*—April 21, 1910; 36; man; colored; laborer. Aneurysm of the ascending aorta of three months' duration. No history of syphilis.

Symptoms and Physical Signs.—Severe pain. Heart 11.5 cm. to the left. Swelling pointing to the right of the sternum.

Operation.—April 22. Dr. J. M. T. Finney. Wiring of aortic aneurysm; 12 feet of wire introduced; galvanic current.

Postoperative Course.—Swelling not reduced, nor pulsation. Pain possibly relieved.

Result.—Improved (?), May 15. No further history.

CASE 108.—*History.*—April 21, 1910; 48; man; colored; widower; laborer. Aneurysm of the ascending aorta of seven months' duration. Syphilis for twenty-one years.

Symptoms and Physical Signs.—Came on after heavy lifting. Pain in the arm and chest. Tumor in the second right interspace, the size of a small lemon.

Operation.—April 22. Dr. J. M. T. Finney. Wiring of aneurysm of the ascending arch of the aorta with 11 feet of wire. Galvanic current.

Postoperative Course.—No relief of pain, nor decrease in the size of the tumor.

Result.—Unimproved, August 11. No further history.

CASE 109.—*History.*—Nov. 30, 1910; 39; man; white; single; bartender. Aneurysm of the ascending aorta of eleven months' duration. Syphilis for ten years; Wassermann reaction positive.

Symptoms and Physical Signs.—Intense pain. Cough. Swelling for eight weeks, pointing as a large mass below the right clavicle. Heart not enlarged.

Operation.—Jan. 6, 1911. Dr. J. M. T. Finney. Wiring of aneurysm with 11 feet of wire; galvanic current.

Postoperative Course.—Aneurysm grew larger. Slight relief from pain for a short time.

Result.—Death, February 9.

Necropsy.—Aneurysm of the arch of the aorta; complete occlusion of the superior vena cava and the right subclavian artery with collateral circulation established; arteriosclerosis and multiple dilatations of the aorta; cardiac dilatation and slight hypertrophy.

CASE 110.—*History.*—Jan. 30, 1911; 44; man; colored; single; laborer. Aneurysm of the ascending thoracic aorta of ten weeks' duration. No history given of either syphilitic or gonorrheal infection; Wassermann reaction positive.

Symptoms and Physical Signs.—Pain and dyspnea. Heart not enlarged. Murmur at the apex. Aneurysm pointing very slightly in the first right interspace.

Operation.—February 6. Dr. J. M. T. Finney. Wiring of thoracic aneurysm with 11 feet of wire; galvanic current up to 40 milliamperes.

Postoperative Course.—Pulsation diminished and pain almost disappeared. No roentgen-ray treatment. No syphilitic treatment.

Result.—Improved, February 24. No further history.

CASE 111.—*History.*—Feb. 9, 1912; 51; man; white; married; foreman. Aneurysm of the ascending aorta of seven months' duration. Syphilis for twenty years; Wassermann reaction positive.

Symptoms and Physical Signs.—Sudden give in the chest when lifting the hands above the head. Tumor pointing in the third right interspace. Slight enlargement of the heart.

Operation.—February 20. Dr. J. M. T. Finney. Wiring aortic aneurysm, ascending arch, with 11 feet of wire; galvanic current.

Postoperative Course.—No improvement. Sudden death without hemorrhage; probably embolus.

Result.—Death, March 5. No necropsy.

CASE 112.—*History.*—July 26, 1912; 42; man; white; married; riveter. Aneurysm of the ascending aorta of six weeks' duration. Syphilis for twenty-two years; Wassermann reaction positive; gonorrheal infection.

Symptoms and Physical Signs.—Severe pain. Tumor noted for one week. Heart normal. Left radial pulse weaker than the right. Blood pressure, left arm 95; right 115. Tumor pointing in the second right interspace.

Operation.—September 11. Dr. J. M. T. Finney. Wiring of thoracic aneurysm; galvanic current.

Postoperative Course.—Severe pain until death.

Result.—Death, September 16.

Necropsy.—Rupture of aneurysm into the pericardial sac. Wire got into the aorta and into the pericardium.

CASE 113.—*History.*—Nov. 25, 1912; 43; man; white; married; plumber. Aneurysm of the ascending thoracic aorta of six years' duration. No history of syphilis; Wassermann reaction very strongly positive.

Symptoms and Physical Signs.—Pain for several years. Tumor mass for fifteen months. A heavy strain one month before the tumor. Blood pressure 132, tracheal tug, and cough. Pulses equal. Heart not enlarged. Tumor pointing in the second interspace to the right.

Operation.—December 3. Dr. J. M. T. Finney. Wiring of aortic aneurysm with 11 feet of wire; galvanic current.

Postoperative Course.—Swelling and pulsation remained about the same. Pain seemed to be greatly relieved. Roentgen-ray examination showed wire in the sac.

Result.—Improved, December 23.

Letter of April 12, 1922, returned; patient deceased.

CASE 114.—*History.*—July 22, 1916; 37; man; white; married; sheriff. Aneurysm of the ascending thoracic aorta of ten months' duration. No history of syphilis; gonorrheal infection twice; Wassermann reaction strongly positive.

Symptoms and Physical Signs.—Onset with a boring pain. Pulsating tumor for four or five months. Dyspnea; orthopnea; cough with occasional blood. Heart normal. Blood pressure, right arm 100/75; left arm 120/60. Big pulsating mass below the right clavicle.

Operation.—July 22. Dr. R. H. Follis. Wiring of aneurysm, ascending arch, with 11 feet of wire; galvanic current.

Postoperative Course.—Death due to rupture of the aneurysm into the right pleural cavity.

Result.—Death, July 26.

Necropsy.—Syphilis. Rupture of the aneurysm of the ascending arch into the right pleural cavity. Wire nicely coiled in the sac.

18. TEN CASES OF ANEURYSM OF THE TRANSVERSE ARCH OF THE AORTA

CASE 115.—*History.*—Nov. 30, 1908; 25; man; white; single; blacksmith. Aneurysm of the arch of the aorta of four and one-half months' duration. No record as to syphilitic history.

Symptoms and Physical Signs.—Severe pain. Aneurysm pointed in the left second interspace.

Operation.—December 18. Dr. J. M. T. Finney. Wiring of aneurysm of the transverse arch of the aorta with 12 feet of wire; galvanic current.

Postoperative Course.—At first there was a slight increase in the size of the aneurysm and its pulsation; later a decrease. On discharge from the hospital the pain was much relieved but there was a diffuse heave to the whole left chest wall. Left radial pulse smaller than the right.

Result.—Improved, April 20, 1909. No further history.

Case 116.—*History.*—Jan. 5, 1909; 49; man; white; married; brush maker. Aneurysm of the transverse portion of the thoracic aorta, of three years' duration. Syphilis for twenty-four years; Wassermann reaction suggestive; gonorrheal infection.

Symptoms and Physical Signs.—Onset with loss of voice and pains. Voice gradually became better, never returned to normal. Later coughing and shortness of breath. Left pupil larger than the right. Tracheal tug. Heart 11.5 cm. to the left. Aneurysm pulsating in the second interspace on the left; dulness but no pulsation in the back. Blood pressure, right arm 134/105; left 127/90.

Operation.—January 20. Dr. J. M. T. Finney. Wiring of thoracic aneurysm from in front; 12 feet of wire introduced; galvanic current.

Postoperative Course.—Improved in spirits. Pain less. Aneurysm recorded as being "smaller and pulsating less forcibly."

Fig. 78.—Method of treating cases of aneurysm of the transverse arch of the aorta.

Result.—Improved, March 2. April, 1922, letter returned; patient dead.

The current was increased only to 10 milliamperes.

Case 117.—*History.*—Nov. 15, 1910; 37; man; white; single; physician. Aneurysm of the transverse aorta of two years' duration. Syphilis for thirteen years; Wassermann reaction negative.

Symptoms and Physical Signs.—Pulsation first noted in 1908. Began syphilitic treatment. Heart normal. Tumor pointing in the left second interspace.

Operation.—November 18. Dr. J. M. T. Finney. Wiring of aneurysm with 12 feet of wire; galvanic current.

Postoperative Course.—No improvement for one month, then a rapid improvement, pain going away, aneurysm pulsating much less.

Result.—Improved, March 3. No further history.

Case 118.—*History.*—Jan. 26, 1911; 36; man; white; married; salesman. Aneurysm of the transverse portion of the thoracic aorta, of one and one-half years' duration. Syphilis for twenty years; Wassermann reaction negative. Gonorrheal infection twice.

Symptoms and Physical Signs.—Pain. Shortness of breath. Cough. Tumor in the left chest pointing in the second interspace. Pain in the arm. Heart normal. Took potassium iodid for two months or longer.

Operation.—January 27. Dr. J. M. T. Finney. Wiring of a thoracic aneurysm (from left front); 10 feet of wire; galvanic current.

Postoperative Course.—Great improvement. Pain disappeared. Aneurysm became smaller and pulsation nonexpansile. Practically all discomfort disappeared. No syphilitic treatment.

Result.—Improved, February 26.

On readmission, May 4, 1911, the patient stated that there had been recurrence of pain and swelling about May 1. Roentgen-ray examination showed the wire in good position.

Second Operation.—May 8. Dr. J. M. T. Finney. Rewiring of recurrent thoracic aneurysm with 10 feet of wire; galvanic current up to 40 milliamperes.

Postoperative Course.—Improvement for three weeks (less pain and tumor more solid) and then a sudden return of pulsation, increase in size, and pain. Roentgen-ray examination showed both wires in good position. No syphilitic treatment.

Third Operation.—June 6. Dr. J. M. T. Finney. Third wiring of thoracic aneurysm; 9 feet; galvanic current.

Postoperative Course.—Aneurysm seemed to become nearly solid, but did not decrease in size. There was some relief. Left the hospital with an open infection over the aneurysm. Roentgen-ray examination showed the wires in good position.

Result.—Not improved, July 17. No further history.

CASE 119.—*History.*—June 13, 1911; 35; man; white; married; electrician. Aneurysm of the ascending, and transverse portions of the thoracic aorta of nine months' duration. No history of syphilis; gonorrheal infection admitted.

Symptoms and Physical Signs.—Heart normal. Severe pain.

Operation.—June 15. Dr. J. M. T. Finney. Wiring of thoracic aneurysm; 11 feet of wire; galvanic current.

Postoperative Course.—Great improvement. Pain relieved. Pulsation less.

Result.—Improved, June 27. No further history.

CASE 120.—*History.*—Nov. 3, 1911; 27; man; colored; married; laborer. Aneurysm of the transverse portion of the arch of the aorta of nineteen months' duration. Syphilis for three years; Wassermann reaction strongly positive.

Symptoms and Physical Signs.—Sharp pain. Later hoarseness and dyspnea. Pulsation in the left second interspace. Heart normal.

Operation.—November 3. Dr. J. M. T. Finney. Wiring of aneurysm of transverse arch with 11 feet of wire; galvanic current.

Postoperative Course.—No relief. Cause of death not stated in the history.

Result.—Death, November 28.

Necropsy.—Syphilitic mesaortitis; aneurysm of the descending thoracic aorta; multiple aneurysms of the thoracic and abdominal aorta; complete thrombosis of the superior mesenteric with collateral circulation established; aneurysmal dilatation with mural thrombus of the right renal artery; aortic insufficiency; cardiac dilatation and hypertrophy; fibrous myocarditis.

CASE 121.—*History.*—Jan. 27, 1912; 43; man; white; single; writer. Aneurysm of the transverse and descending aorta of one year and four months' duration. Syphilis for several years; Wassermann reaction positive.

Symptoms and Physical Signs.—Extreme pain. Heart normal. Tumor pointing in the left second interspace. Mass one-half the size of the fist.

Operation.—March 6. Dr. J. M. T. Finney. Wiring aneurysm of transverse and descending arch of the aorta with 11 feet of wire.

Postoperative Course.—No improvement. Rapid growth and rupture of aneurysm after ulceration.

Result.—Death, May 5.

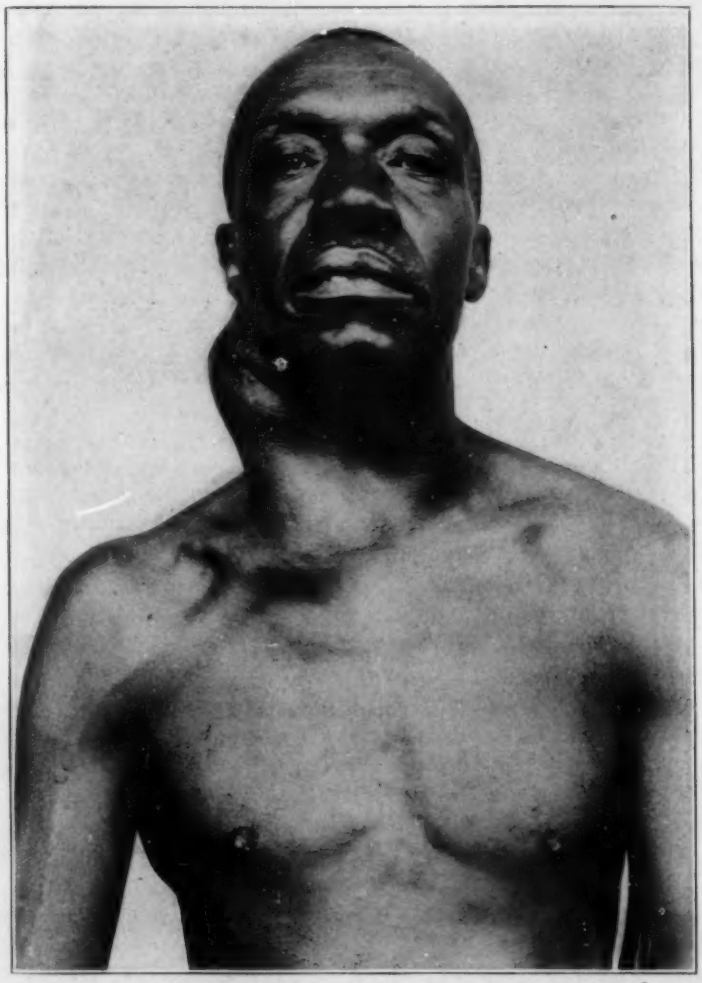

Fig. 79.—Aneurysm of the thoracic aorta presenting in the neck in Case 123.

Necropsy.—Syphilitic aortitis; aneurysm involving the ascending and transverse arch of the aorta eroding the ribs and sternum and producing a large saccular tumor beneath the skin of the anterior chest; hypertrophy of the left ventricle.

Case 122.—*History.*—Sept. 11, 1912; 44; man; colored; laborer. Aneurysm of the transverse arch of the aorta of one year's duration. No history of syphilis. Wassermann reaction positive; gonorrheal infection.

Symptoms and Physical Signs.—Pain. Swelling pointing to the right and left of the sternum, more to the left, in the second interspace. Heart normal.

Operation.—October 1. Dr. J. M. T. Finney. Wiring of aortic aneurysm; galvanic current.

Postoperative Course.—Terminal hematemesis. Pulsation not reduced. Pain perhaps a little relieved.

Result.—Death, November 2.

Necropsy.—Syphilitic aortitis; aneurysm of the arch of the aorta with compression of the right bronchus; erosion of the thoracic vertebrae and rupture into the esophagus.

CASE 123.—*History.*—July 7, 1921; 52; man; colored; married; barber. Aneurysm of the ascending and transverse thoracic aorta of six years' duration. Chancre twenty years before admission. Wassermann reaction negative.

Symptoms and Physical Signs.—Pain (intermittent in character) for three years; then a small swelling growing gradually up into the neck; causing more pain in the neck and arm. Blood pressure right arm, 180/110; left arm, 220/135. Arteriosclerosis. Heart 12 cm. to the left. Compensated. Aneurysm presented high in the neck, resembling a carotic aneurysm.

Operation.—July 16. Dr. M. R. Reid. Wiring of aneurysm with 11 feet of wire. Galvanic current up to 40 milliamperes. Wiring done in the neck.

Postoperative Course.—Physical signs unchanged. Patient said the pain was less. Roentgen-ray examination showed wire in good position.

Result.—Improved (?), July 28.

Very unusual presentation of aneurysm.

CASE 124.—*History.*—June 10, 1921; 25; man; colored; single; laborer. Aneurysm of the transverse thoracic aorta of ten months' duration. Syphilitic scars on the penis; Wassermann reaction negative.

Symptoms and Physical Signs.—Onset with severe pain behind the ears. Swelling observed for four months, beginning after chopping wood. Severe pain. Large swelling the size of a grapefruit presenting in the center and left of the neck just above the sternum. Very tense; skin shiny. Radials equal. Heart not enlarged. Sounds clear. Roentgen-ray examination showed a large aneurysm.

Operation.—July 16. Dr. M. R. Reid. Unsuccessful attempt to wire a thoracic aneurysm. Unable on four attempts to find the cavity of the aneurysm.

Postoperative Course.—Gradual increase; ulceration, and hemorrhage.

Result.—Death, August 26.

Necropsy.—Aneurysm of the ascending arch of the aorta. Erosion of the upper third of the sternum. Ulceration and hemorrhage through the chest wall with a mass of clot at the site of the ulceration. Syphilitic aortitis. Secondary anemia. Focal necrosis of the liver. Fibrotic infarction of the left kidney. Bilateral bubo scar.

19. EIGHT CASES OF ANEURYSM OF THE DESCENDING ARCH OF THE AORTA

CASE 125.—*History.*—May 10, 1912; 33; man; colored; widower, laborer. Aneurysm of the descending arch of the aorta of one month's duration. No history of syphilis; Wassermann reaction negative.

Symptoms and Physical Signs.—Severe pain between the spine and shoulder blade. Left pupil larger than the right. Tumor pointing between the left scapula and spine in the back, 11 cm. in diameter. Heart normal.

Operation.—May 27. Dr. J. M. T. Finney. Wiring of thoracic aneurysm. Galvanic current.

Postoperative Course.—Pain not alleviated.

Result.—Improved (?), June 20. No further history.

CASE 126.—*History.*—Dec. 20, 1912; 40; man; white; married; laborer. Aneurysm of the descending thoracic aorta of four months' duration. No history of syphilis; gonorrheal infection; Wassermann reaction positive.

Symptoms and Physical Signs.—Heart 13 cm. to the left; heaving. Aortic insufficiency. Pulsation in back at the vertebral border of the scapula. Pain, shortness of breath and constriction of the chest.

Operation.—December 20. Dr. J. M. T. Finney. Wiring of aneurysm (left back) with 11 feet of wire; galvanic current.

Postoperative Course.—Pain somewhat relieved. Slight decrease in pulsation. Some fluid in the left side of the chest. Patient left the hospital unable to be up without severe pain. Still required morphin. Roentgen-ray examination showed wire in the sac.

Result.—Improved, February 10. Died, April 15.

CASE 127.—*History.*—March 20, 1913; 28; man; white; married; stonecutter. Aneurysm of the descending thoracic aorta of six week's duration. No history of syphilis; gonorrheal infection; Wassermann reaction very strongly positive.

Fig. 80.—Method of treating cases of aneurysm of the descending arch of the aorta.

Symptoms and Physical Signs.—Severe pain. Cough. Pulsating mass in the left second interspace. Heart 13.5 cm. to the left. Slight murmur. No pulsation in the back. Blood pressure 125, equal on both sides.

Operation.—March 24. Dr. J. M. T. Finney. Wiring of aneurysm (from in front) with 11 feet of wire; galvanic current. Wire introduced with difficulty on account of kinking. Difficult also to hit the sac with the needle. Severe pain during the electric current.

Postoperative Course.—No improvement; pain continued and aneurysm grew, gradually bleeding externally.

Result.—Death, May 27. No information as to the findings at necropsy.

CASE 128.—*History.*—April 8, 1913; 40; man; white; married; tailor. Aneurysm of the descending thoracic aorta of three months' duration. No history of syphilis; gonorrheal infection. In the Wassermann test there was slight fixation.

Symptoms and Physical Signs.—Pain, shortness of breath, cough, expectoration (occasionally blood tinged), hoarseness. Three injections of arsphenamin. Heart 9 cm. to the left. Slight murmur. Radial pulses equal. Retromanubrial dulness. Pulsation in the second left interspace.

Operation.—April 18. Dr. J. M. T. Finney. Wiring of aneurysm with 11 feet of wire; galvanic current up to 50 milliamperes. Wired from the second interspace left.

Postoperative Course.—Apparent improvement, until sudden death thought due to intrathoracic rupture of aneurysm.

Result.—Death, May 4. No necropsy.

CASE 129.—*History.*—Sept. 18, 1914; 44; man; colored; married; laborer. Aneurysm of the descending thoracic aorta of three months' duration. No history of syphilis; gonorrheal infection.

Symptoms and Physical Signs.—Pain in the shoulder, hemoptysis. Tracheal tug. Pulsating mass in the left interscapular space. Heart 11 cm. to the left. No murmurs.

Operation.—October 23. Dr. J. M. T. Finney. Wiring of aneurysm with 11 feet of wire; galvanic current. Wired from the back.

Postoperative Course.—Gradually a complete relief from pain. Aneurysm became smaller and pulsation almost nonexpansile. Syphilitic treatment. roentgen-ray examination showed wire in sac, but pulsation still present on discharge.

Result.—Improved, Feb. 11, 1915. No further history.

CASE 130.—*History.*—July 20, 1915; 45; man; colored; married. Aneurysm of the descending thoracic aorta of approximately one year's duration. Syphilis for twelve years; gonorrheal infection; Wassermann reaction negative.

Symptoms and Physical Signs.—Swelling noted after severe coughing seven months before admission; then pain ("rheumatism" in the shoulder). Tumor below the right clavicle 11 by 11 cm. Heart 12 cm. to the left. Systolic murmur. Pulses equal. Blood pressure, right arm 135/100, left arm 145/100.

Operation.—July 21. Dr. R. H. Follis. Wiring aneurysm of the arch of the aorta with 11 feet of wire; galvanic current.

Postoperative Course.—Slight improvement after operation until August 13, when condition seemed to grow worse.

Second Operation.—August 20. Dr. R. D. McClure. Aneurysm rewired with 12 feet of wire; galvanic current.

Postoperative Course.—Death thought to be due to pulmonary edema.

Result.—Death, August 27.

Necropsy.—A few loops of wire extended through the aortic ring into the ventricle. Infarcts in the kidney. Extensive clot in the aneurysm. Atelectasis of the lung.

CASE 131.—*History.*—Feb. 8, 1917; 42; man; white; married; salesman. Aneurysm of the descending thoracic aorta of three years' duration. Syphilis for twenty-three years; Wassermann reaction very strongly positive.

Symptoms and Physical Signs.—Onset with a severe pain after cranking automobile, also tingling in the left arm. Cough. Extensive treatment with potassium iodid and arsphenamin. Heart normal. Large heaving pulsation in the left interscapular space. Blood pressure left arm 132/78, right 126/74.

Operation.—February 9. Dr. J. M. T. Finney. Wiring of aneurysm of the descending aorta (from the left back) with 11 feet of wire; galvanic current.

Postoperative Course.—Subjectively greatly improved. Objectively no change. Roentgen-ray examination showed the wire in proper place. Pain seemed to have been greatly relieved.

Result.—Improved subjectively, February 19.

CASE 132.—*History.*—May 6, 1893; 44; man; colored; married; laborer. Aneurysm of the descending thoracic aorta of five years' duration. Syphilis fifteen years before admission.

Symptoms and Physical Signs.—Large swelling in the interscapular region. Heart not enlarged.

Operation.—June 11. Dr. W. S. Halsted and others. Macewen's needle operation. Certainly as many as forty needlings before death. No infections.

Postoperative Course.—Patient felt better and became more comfortable. Tumor not much changed.

Result.—Death, August 12.

Necropsy.—Rupture of the aneurysm into the left pleural cavity.

20. EIGHT CASES OF ANEURYSM OF THE ABDOMINAL AORTA

CASE 133.—*History.*—Nov. 18, 1897; 27; man; white; single; printer. Aneurysm of the abdominal aorta of four or five years' duration. No information as to probable etiology.

Symptoms and Physical Signs.—Abdominal pain for four or five years, occasionally in the legs and pelvis. Pain over the heart for two or three days. Heart normal. Tumor, 5 cm. in diameter, in the epigastric region.

Operation.—November 24. Dr. W. S. Halsted. Laparotomy. Corradi's operation; combined wiring and electrolysis. Needle introduced three times: first — wire kinked; second — 17 inches (42.5 cm.) introduced and then kinking; third — 38 inches (96.4 cm.) introduced and then kinking.

Postoperative Course.—Death from rupture into the thoracic cavity. Vertebrae eroded. Big vessels came off the sac. Wire was in contact with the point of rupture.

Result.—Death, November 26.

Necropsy.—Saccular aneurysm of the abdominal aorta; perforation into the left pleural cavity; moderate arteriosclerosis with atheroma of aorta.

CASE 134.—*History.*—Jan. 26, 1900; 30; man; white; single; machine agent. Aneurysm of the abdominal aorta of ten months' duration. No history of syphilis; gonorrheal infection for five years.

Symptoms and Physical Signs.—Pain, pulsation and swelling. Heart normal. Pulse in the feet, more easily felt in the right than in the left.

Operation.—January 26. Dr. J. M. T. Finney. Wiring of the abdominal aneurysm through an abdominal incision.

Postoperative Course.—No appreciable change noted in the aneurysm after operation.

Result.—Improved, March 8. Death in January, 1904, from rupture of the sac.

Necropsy.—Saccular aneurysm of the aorta; rupture of the aneurysmal sac.

CASE 135.—*History.*—May 11, 1900; 36; man; white; lawyer. Aneurysm of the abdominal aorta of one year and eight months' duration. No history of syphilis; gonorrhea three times.

Symptoms and Physical Signs.—Loss of forty pounds (18.1 kg.) in weight. Slight murmur of the heart. Point of maximum impulse in the fifth interspace. Bulging epigastrium.

Operation.—May 14. Dr. J. M. T. Finney. Laparotomy; wiring of abdominal aneurysm with 11 feet of silver wire.

Postoperative Course.—Rupture of the sac on the ninth day after operation. Severe pain, not relieved.

Result.—Death, May 22.

Necropsy.—Rupture of wired aneurysm with hemorrhage; saccular aneurysm of the first part of the arch. Arteriosclerosis. Syphilis? Horseshoe kidney.

CASE 136.—*History.*—Oct. 13, 1900; 53; man; white; married; laborer. Aneurysm of the abdominal aorta of three years' duration. Syphilis for thirty-six years; not treated.

Symptoms and Physical Signs.—Pain in the "stomach" for three years. Pulsation in the stomach in April, 1900. Heart normal.

Operation.—October 19. Dr. J. M. T. Finney. Wiring of large sacculated abdominal aneurysm with 11 feet of wire; 10 milliamperes for one hour. Aneurysm 15 by 9 cm., sacculated.

Postoperative Course.—No appreciable change in the aneurysm.

Result.—Improved (?), November 6. No further history.

The aneurysm was above the stomach, probably above the celiac axis.

CASE 137.—*History.*—Nov. 16, 1900; 34; man; white; single; carpenter. Aneurysm of the abdominal aorta of two years' duration. Syphilis for four years; gonorrheal infection twice.

Symptoms and Physical Signs.—Pain began in the back. Gelatin injection one year before admission (Massachusetts General Hospital). Incapacitated for six months. Heart normal.

Operation.—November 16. Dr. J. M. T. Finney. Laparotomy. Wiring of aneurysm with 10 feet of wire; 10 milliamperes for one hour fifteen minutes.

Postoperative Course.—Unrelieved. Rupture and death thirteen days later.

Result.—Death, December 1. No necropsy.

CASE 138.—*History.*—Nov. 13, 1902; 43; man; white; married; pilot. Aneurysm of the abdominal aorta of five years' duration. No history of syphilis.

Symptoms and Physical Signs.—Heart enlarged — 12 cm. from midsternal line. Tumor pointing in the epigastrium.

Operation.—November 14. Dr. J. M. T. Finney. Celiotomy and wiring of abdominal aneurysm with 11 feet of wire; 10 milliamperes for one hour.

Postoperative Course.—Very severe pain after operation. Condition appeared to have become rapidly worse.

Result.—Unimproved, December 10. No further history.

CASE 139.—*History.*—March 28, 1914; 66; woman; colored; married; housewife. Aneurysm of the abdominal aorta of seven weeks' duration. No history of syphilis; Wassermann reaction positive.

Symptoms and Physical Signs.—Patient had suffered for several years with trigeminal neuralgia. Alcohol injection and other treatments had been given. Abdominal symptoms for six weeks coming on after pneumonia. On admission only an umbilical hernia was found. Two days before operation the aneurysm in the left hypochondrium was discovered, measuring 13 by 16 cm. Heart 12 cm. to the left.

Operation.—April 14. Dr. G. J. Heuer. Exploratory laparotomy. Wiring of abdominal aneurysm the size of a grapefruit; 14 feet of wire; galvanic current up to 50 milliamperes.

Postoperative Course.—Aneurysm continued to grow rapidly. Death due to intra-abdominal rupture, April 21. No syphilitic treatment.

Result.—Death, April 21.

Necropsy.—Syphilitic aortitis; arteriosclerosis; aneurysm of abdominal aorta; perforation of aneurysm into the abdominal cavity; chronic fibrous myocarditis; cardiac hypertrophy and dilatation.

CASE 140.—*History.*—Jan. 26, 1917; 33; man; white; married; salesman. Aneurysm of the abdominal aorta of two and one-half months' duration. Syphilis for fifteen years; gonorrheal infection twice; Wassermann reaction negative.

Symptoms and Physical Signs.—Pain. Gas eructations, etc. Lump below the left costal margin for two months, rapidly growing. Heart normal. Tumor 10 by 9.3 cm. Pulsation in the legs normal.

Operation.—January 31. Dr. W. E. Dandy. Wiring of abdominal aneurysm with 11 feet of wire; galvanic current to 40 milliamperes. Needle thrust through the abdominal wall.

Postoperative Course.—Death at 10 p. m. on the day of operation. Operation done as an emergency because of severe pain, rapid weakness and pallor. Pulse 150; otherwise the abdomen would have been opened.

Result.—Death, January 31.

Necropsy.—Abdominal aneurysm weeping into the abdominal cavity. Wire in good position.

21. ONE CASE OF ANEURYSM OF THE INNOMINATE ARTERY

CASE 141.—*History.*—Dec. 21, 1916; 28; man; colored; married; laborer. Aneurysm of the innominate artery of seven months' duration. Syphilis for ten years, with no history of treatment; Wassermann reaction strongly positive.

Symptoms and Physical Signs.—Heart normal. Ptosis of the right eyelid. Right pupil small. Right radial pulse just perceptible. Blood pressure, right arm 80; left arm 118/80. Hoarseness. Shooting pains in the arm and shoulder. Expectoration of blood. Weak temporal pulse. Very large aneurysm filling half the neck, extending under the sternum and clavicle and weeping into the trachea. Roentgen-ray examination diagnosis: aneurysm of the transverse arch of the aorta.

Operation.—December 30. Dr. M. R. Reid. Wiring of the innominate aneurysm; 11 feet of wire; electric current.

Postoperative Course.—Inability to swallow. Gradual death. No help from wiring. Not a terminal hemorrhage.

Result.—Death, Jan. 12, 1917.

Necropsy.—Aneurysm of the innominate artery weeping into the trachea and extending to the arch.

22. ONE CASE OF ANEURYSM OF THE MESENTERIC ARTERY

CASE 142.—*History.*—Aug. 26, 1898; 28; man; white; single; bookkeeper. Aneurysm of the superior mesenteric artery of one year's duration. History of syphilis questionable; gonorrheal infection for four years.

Symptoms and Physical Signs.—Onset with pain, later soreness. Jaundice at one time. Tumor the size of an apple. Heart normal. Slight pulse in the posterior tibial.

Operation.—August 27. Dr. J. M. T. Finney. Laparotomy. Wiring of aneurysm with 5 feet of wire; galvanic current 70 milliamperes one hour ten minutes.

Postoperative Course.—Breaking down of the skin wound. Intense pain. Back burn due to the electrode. Pain never relieved. Rupture of aneurysm and external bleeding, September 16.

Result.—Death, September 16.

Necropsy.—Aneurysm of the superior mesenteric artery. Hemorrhage from the sac into the duodenum. Arteriosclerosis. Necrosis of the pancreas. Nephritis.

SUMMARY

1. *Ligations of the Aorta.*—In five patients seven ligations of the aorta were performed. Metallic bands and broad tapes were used for ligatures. Three ligations were above the diaphragm, two partial, one complete. The abdominal aorta was partially ligated three times, completely once. All patients died. One patient died twelve hours after operation; the others lived from forty to 134 days. In three instances (two tapes and a band) it is known that the ligature cut through the arterial wall. However, in only one case (thoracic aorta) did the cutting through lead to a fatal hemorrhage. In another instance it is known that the metallic band (just above the renal arteries) had not cut through at the end of forty-nine days. In two other instances the necropsy record does not tell us if the bands (present eighteen and forty days) had cut through the arterial wall. In the other, or seventh instance, the patient died one-half day after the operation. The artery was so sclerotic that the ligatures cut it, resulting in a sharp hemorrhage at the time of operation.

In no instance did either the partial or complete ligation of the aorta cause gangrene or marked circulatory disturbances. Even when the ligation was above the renal arteries or above the diaphragm there occurred no infarction of the intestines and the kidneys continued normal function.

Patient 6 lived for 134 days and permitted us to make interesting observations as to the effect of the ligatures on the vessel wall, and on the blood pressures and surface temperatures of the extremities (Figs. 8 and 9). The rise in the diastolic and the fall in the systolic pressures of the legs corresponded with our observations on the effect of partially occluding bands placed on the aorta of dogs. In the case of this patient the pulse pressure practically disappeared from the legs even though the diastolic pressure remained high.

Thus it will be seen that regardless of the type of operation used for femoral aneurysms, the results have been good and that no gangrene has occurred. I believe that Antyllus' old operation is the best for femoral aneurysms. After the sac is incised, the clot evacuated, and the artery ligated on both sides of the aneurysm as close to it as one can find healthy vessel, no attempt should be made to obliterate the sac. Drainage is not employed. When the tourniquet cannot be used and a large branch,

such as the profunda, enters the aneurysmal sac, simultaneous ligation of the artery on both sides of the aneurysm is perhaps the best.

Popliteal Aneurysms (Sixteen Cases).—Of these one patient died and fifteen recovered. The death occurred in 1895 and was due to mercuric chlorid poisoning, resulting from irrigating the wound with 1 : 1,000 mercuric chlorid solution. In three instances, gangrene developed following the operation. One patient was admitted with an infected aneurysm and a gangrene of the leg; immediate amputation of the leg was done. The types of operation were: 1. Proximal ligation of the artery, four times; gangrene, once. 2. Excision, three times; one death from mercuric chlorid poisoning, no gangrene. 3. Proximal ligation of the artery and later excision of the aneurysm, once. 4. Antyllus' operation, twice; gangrene, once. 5. Proximal ligation of the artery and intrasaccular suture of openings into the aneurysm, once. 6. Matas' reconstructive operation, once; gangrene due to gas bacillus infection. 7. Excision of the aneurysm with end-to-end anastomosis of the artery, once. 8. Incision of the aneurysm and end-to-end anastomosis of the artery, once. 9. Amputation, once; gangrene already present.

Paralysis of the foot followed one operation. The usefulness of the legs in the cases in which the patients were cured has been difficult to determine for we have been able to locate very few of these patients.

Innominate Aneurysms (Three True Cases, Two False Diagnoses).—Of the true innominate aneurysms, two were operated on; one was improved by ligating first the innominate artery and later the carotid artery. One patient died on the operating table, apparently as the result of pulling on the arch of the aorta.

In one case the innominate and subclavian arteries were tortuous and sclerotic, and there was no true aneurysm. However, a band applied to the carotid artery relieved the patient's headaches. In the other case of mistaken diagnosis, the aneurysm arose from the arch of the aorta and did not involve the innominate artery. In this case the right common carotid artery was ligated and divided.

Recently a patient, in the Cincinnati General Hospital, suffering intensely from a large innominate aneurysm was completely relieved by removing the manubrium and ligating the common carotid and subclavian arteries. The aneurysm involved the innominate artery all the way to the aorta.

Carotid Aneurysms (Twelve Cases).—Ten of these were of the common, one of the external and one of the internal carotid vessels.

The results were bad in this group. Only four patients are known to have been cured and in one of these cases (Case 45) the diagnosis of aneurysm was uncertain. Excision of the aneurysm one month after

proximal ligation of the artery, distal ligation of the artery two and a quarter months after proximal ligation, and proximal ligation of the artery were the operative procedures employed in the cases in which the patients were cured. In the other cases in which the result was "death," "improved" or "unknown," ligations of the artery on one or both sides of the aneurysm were done.

My impression is that carotid aneurysms, though usually helped, are frequently not cured by a proximal ligation of the artery. In such cases the subsequent distal ligation of the artery may not cure, especially if the interval between the two operations has been too long.

Simultaneous ligation of the arteries proximal and distal to the aneurysm, or proximal ligation of the artery followed by early excision

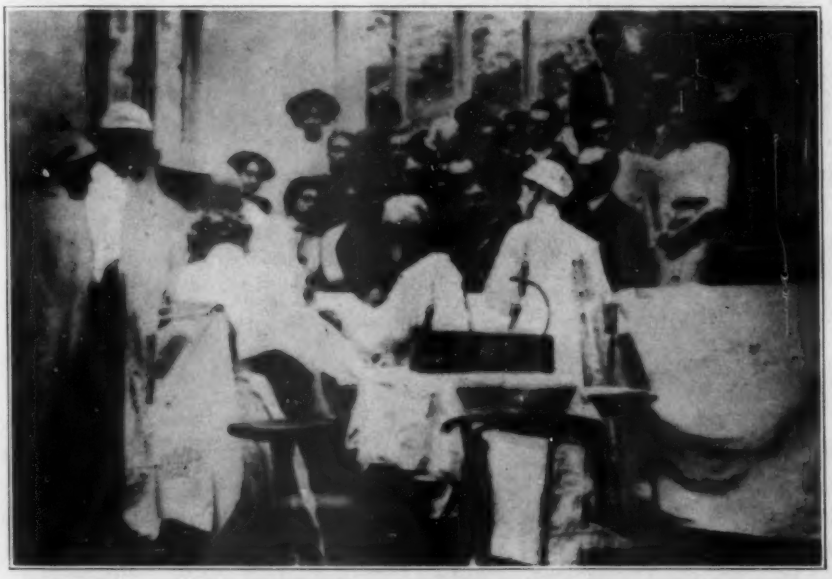

Fig. 81.—Dr. W. S. Halsted operating in Kocher's Clinic for an abdominal aneurysm; a metallic band was applied just above the renal arteries.

of the aneurysm, or an early distal ligation would appear to be the best procedures for carotid aneurysms.

The use of the metallic band will permit of varying degrees of occlusion of the vessel. These constricting bands can, if necessary, be removed during the first few days following the operation and thus restore the cerebral circulation.

Subclavian Aneurysms (Five Cases).—Three were on the right side and two were on the left. In four instances cures were obtained; in another, the ultimate result is not known. Complete excision of the aneurysm was done twice. In the other cases ligatures were used. The

innominate artery was ligated twice in this group of cases, and the first portion of the left subclavian artery was ligated twice.

Axillary Aneurysms (Two Cases).—In one instance excision of the aneurysm was done; in the other, ligation of the third portion of the subclavian artery. Both patients were cured.

Aneurysms of the Brachial Artery (One Case).—The aneurysm was excised and an end-to-end anastomosis of the artery was done. The pulse in the hand remained good.

Aneurysms of the Vertebral Artery (Two Cases).—One patient was cured by a ligation of the artery proximal to the aneurysm and a later ligation distal to it. In this case there was a marked paralysis of both arms due to the effect of the aneurysm on the spinal cord. In the other case the aneurysm was intracranial; death followed two days after ligation of the vertebral artery.

Aneurysms of the Temporal Artery (One Case).—Improvement followed the ligation of the common carotid artery.

Aneurysms of the Radial Artery (Three Cases).—All patients were cured, one by ligation, two by excision.

Aneurysms of the Ulnar Artery (Three Cases).—All patients were cured, one by ligation, two by excision.

Aneurysm of the Posterior Tibial Artery (One Case).—The patient was cured by ligation of the artery.

Aneurysms of the Dorsalis Pedis Artery (Three Cases).—All the patients were cured by excision.

It may be of interest to surgeons to present here illustrations of the late Dr. Halsted applying a metallic band to the abdominal aorta at Kocher's Clinic in 1910, and of the result of this operation six weeks later. The aneurysm was apparently cured and the patient was walking from the hospital when she collapsed and died from a rupture of the aorta, with fatal hemorrhage, at the site of the band (Figs. 81 and 82).

Iliofemoral Aneurysms (Five Cases).—Four patients were cured; one died eight days after partial occlusion of the external iliac. Necropsy showed a pneumonia, and a thoracic aneurysm about to rupture into the trachea. In one case a complete ligation of the common iliac artery resulted in a cure. In the three other cases a preliminary partial occlusion of the external iliac artery, followed later by complete ligations peripheral to the aneurysm in one case, extirpation of the aneurysm in one, and Antyllus' operation in another, resulted in cures. In no cases did gangrene occur. One patient a year after operation had slight evidences of intermittent claudication. When seen two and six years later there was no evidence of it. For the partial occlusions of the arteries, the aluminum band was used.

Femoral Aneurysms (Ten Cases).—All aneurysms were cured. The types of operation used were: 1. Excision of aneurysm, once. 2. Ligation of artery just proximal to the aneurysm, twice. 3. Ligation of artery just above and below the aneurysm without incision of the sac, twice. 4. Ligation just above and below the aneurysm with incision of

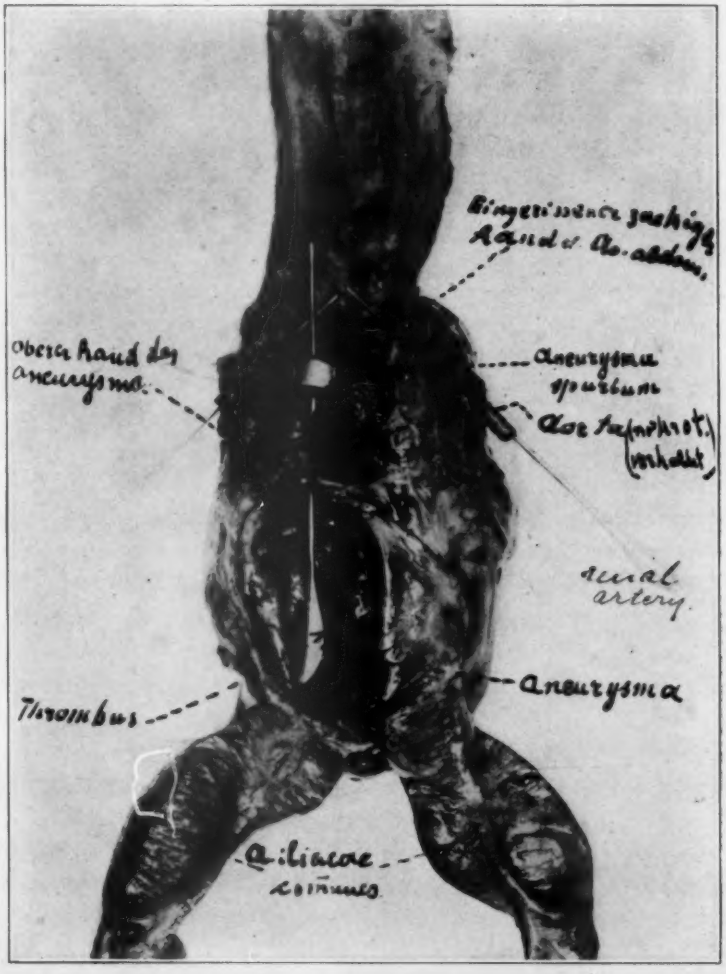

Fig. 82.—Appearance six weeks after Halsted's operation: the band cut through the aorta causing a fatal hemorrhage. The aneurysm was almost cured. (Albert Kocher sent this photograph to Dr. Halsted in 1921.)

the sac, three times. 5. Preliminary partial ligation of the proximal artery with a metallic band, followed later by an incision of the sac and ligation of the vessels, once. 6. Incision of the sac and a restoration of the artery, once (a traumatic case).

Abnormal Arteriovenous Communications (Twenty-Six Cases).—There were six cases of pulsating angiomas—cirsoid aneurysms, racemose aneurysms, aneurysm by anastomosis, etc., two in the hand, one in the eyelid, two in the head, and one within the brain, and twenty cases of arteriovenous aneurysms, eight femoral, five intracranial, three subclavian, two carotid, one occipital, and one tibial. A patient with a femoral arteriovenous aneurysm died as a result of pulmonary infarction of the lung. A patient with a case of cortical cirsoid aneurysm died from hemorrhage at the time of operation. Of the other patients, twenty-one were cured and three were improved. Amputation of the leg was necessary in three instances.[3]

Wired Aneurysms (Forty Cases).—Eight of these cases were of the abdominal aorta; twelve of the ascending arch of the aorta; ten of the transverse arch of the aorta; eight of the descending arch of the aorta; one of the innominate artery, and one of the superior mesenteric artery. No patient was cured. Possibly five patients were relieved by the operation. Many results checked as improved on the front sheets of the histories were not substantiated by a more careful study of the cases.

Macewen's Needle Operation.—This was used in one case of aneurysm of the descending aorta. The result was death.

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3. Reid (Footnote 2); Abnormal Arteriovenous Communications, Acquired and Congenital, II, The Origin and Nature of Arteriovenous Aneurysms, Cirsoid Aneurysms and Simple Angiomas, Arch. Surg. **10**:996 (May) 1925.

ACUTE BONE ATROPHY *

THOMAS P. NOBLE, M.D. AND EMIL D. W. HAUSER, M.D.
ROCHESTER, MINN.

We wish to add further proof to the existence of a type of acute bone atrophy which appears much more rapidily and is more extensive than that following disuse. In many cases of this type, there has been no inactivity. Such atrophies may occur as a complication of injuries to the ankle or knee joints, or a Colles' fracture. The results of treatment of such injuries are so uniformly good that one is likely to overlook the exceptional cases in which convalescence is prolonged, and pain and stiffness of the hand or foot with trophic changes persist for many months. Pain dominates the clinical picture, and the roentgenologic findings are very definite, and quite distinct from those of chronic bone atrophy.

REVIEW OF THE LITERATURE

Acute bone atrophy was first established as a definite clinical entity, in 1900, by Sudeck.[1] He clearly demonstrated that there were two types of bone atrophy, the acute and the chronic, which differed very materially.

Previous to this, in 1877 and 1883, Wolff [2] described cases following infection or resection of a joint in which, in the adult, there was a decrease in the size of the limb, with trophic changes, and, in the adolescent, an interference with growth, with trophic changes. Cassirer,[3] in 1902, made a study of vasomotor trophoneurosis, and analyzed the cases described by Wolff. He concluded that Wolff's cases were merely the end-product of bone atrophy. Also, previous to Sudeck's original description of acute bone atrophy in the distal portions of the limbs, cases had been observed in the spine, and, in 1895, six cases were described by Kümmell [4] following slight trauma.

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* From the section on orthopedic surgery, Mayo Clinic.

1. Sudeck, P.: Ueber die akute entzündliche Knochenatrophie, Arch. f. klin. Chir. **62**:147-156, 1900.

2. Wolff, Julius: Ueber einen Fall von Ellenbogengelenks-Resection, Arch. f. klin. Chir. **20**:771-795, 1877; Ueber trophische Störungen bei primären Gelenksleiden, Berl. klin. Wchnschr. **20**:418; 422-426, 1883.

3. Cassirer, R.: Die vasomotorisch-trophischen Neurosen, Berlin, S. Karger, 1912, pp. 101-113.

4. Kümmell, H.: Ueber die traumatischen Erkrankungen der Wirbelsäule, Deutsch. med. Wchnschr. **21**:180-181, 1895.

Further papers appeared, in 1902, by Sudeck [5] and by Kienböck.[6] Both authors added further to their previous clinical description, and gave accurate roentgenologic findings of this type of atrophy. They showed clearly that inactivity could not account for the degree of atrophy, that it appeared much earlier than the atrophy of disuse, and that in certain cases the condition came on while the limb was still in use. In the same year, Exner [7] added further to the knowledge of this condition by an accurate microscopic and chemical study of some of the atrophic bones. Nonne [8] studied the effect of nerve lesions on bone atrophy, and concluded that bone atrophy is found in such cases, whereas in the past, only trophic changes in the soft parts had been recognized.

In 1917, Ohlmann [9] added further to our knowledge by an accurate roentgen-ray description of the acute and chronic bone atrophies. Hilgenreiner [10] disputed the existence of acute bone atrophy; he studied the atrophy following gunshot wounds, and believed he could explain all his cases and those reported in the literature as acute bone atrophy, solely the result of inactivity.

Acute bone atrophy following frost-bite was described by Hitschmann and Wachtel,[11] in 1909, and following burns by Dubs,[12] in 1921. The latter writer pointed out that the extent and appearance of bone atrophy bears no relationship to the extent or degree of the burns, and that the symptoms of bone atrophy persisted long after the burns had disappeared.

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5. Sudeck, P.: Ueber die akute (reflektorische) Knochenatrophie nach Entzündungen und Verletzungen an den Extremitäten und ihre klinischen Erscheinungen, Fortschr. a. d. Geb. d. Röntgenstrahlen **5**:277-293, 1901-1902; Ueber die akute (trophoneurotische) Knochenatrophie nach Entzündungen und Traumen der Extremitäten, Deutsch. med. Wchnschr. **28**:336-338, 1902.

6. Kienbök, R.: Ueber Knockenveränderungen bei gonorrhoischer Arthritis und akute Knochenatrophie überhaupt, Wien. klin. Wchnschr. **16**:57-63; 99-105, 1903.

7. Exner, A.: Beiträge zur Kenntnis der akuten Knochenatrophie, Fortschr. a. d. Geb. d. Röntgenstrahlen **6**:1-12, 1902-1903.

8. Nonne: Ueber radiographisch nachweisbare akute und chronische "Knochenatrophie" (Sudeck) bei Nerven-Erkrankungen, Fortschr. a. d. Geb. d. Röntgenstrahlen **5**:293-297, 1901-1902.

9. Ohlmann, J.: Ueber die Sudecksche Knochenatrophie, Fortschr. a. d. Geb. d. Röntgenstrahlen **24**:517-528, 1916-1917.

10. Hilgenreiner, H.: Die Knochenatrophie nach Schussfrakturen der Extremitätenknochen und ihre diagnostische, prognostische und funktionelle Bedeutung, Beitr. z. klin. Chir. **112**:473-509, 1918; Gibt es eine Sudecksche Knochenatrophie? ibid. **129**:683-699, 1923.

11. Hitschmann, F., and Wachtel, H.: Die sogenannte Sudecksche Knochenatrophie als häufige Folge der Erfrierungen, Fortschr. a. d. Geb. d. Röntgenstrahlen **27**:621-623, 1919-1921.

12. Dubs, J.: Ueber Sudecksche Knockenatrophie nach Verbrennungen, München. med. Wchnschr. **68**:1141 (Sept. 9) 1921.

Quite recently, in 1923, Turner [13] pointed out that this condition followed Colles' fracture, and demonstrated the possibility of sensory nerve involvement, particularly the dorsal interosseous nerve, and the dorsal cutaneous branch of the ulnar nerve, and that the bone atrophy is mainly on the ulnar side of the hand.

EXPERIMENTAL DATA

Much experimental work has been done with a view to finding out what factors have a bearing on bone atrophy. The atrophy produced experimentally has been mostly of the chronic type, or the atrophy of disuse, but that produced by Pawlow,[14] Lapinsky,[15] and Lewaschew [16] is in all probability of the acute type.

The experimental work of Grey and Carr [17] and Allison and Brooks [18] throws much light on the factors at work in bone atrophy. These experimenters studied bone atrophy in relation to nerve injuries, vascular changes, and simple disuse from fixation in plaster-of-Paris casts. Legg [19] has gone further and infected various joints, and studied the atrophy produced with infection alone, and infection with fixation. As regards the relationship to nerve injuries, various experiments have been carried out. The posterior roots of the lumbar cord were divided, in dogs, by Grey and Carr, and the amount of atrophy noted; no appreciable atrophy appeared up to two and one-half months, but if the anterior roots were also cut, atrophy appeared in six weeks, as shown by the disappearance of the bony trabeculae. Peripheral nerves also were sectioned. One centimeter of the sciatic nerve was excised, and slight changes appeared after one and one-half months, but if, in addi-

13. Turner, H.: Ueber Nervenschädigungen beim typischen Radiusbruch, Arch. f. klin. Chir. **128**:422-436, 1924.

14. Pawlow, quoted by Gantt, W. H.: A Medical Review of Soviet Russia, Brit. M. J. **2**:533-536, 1924.

15. Lapinsky, M.: Zur Frage über die Beteiligung der Nervenstämme der hinteren Extremität an der vasomotorischen Innervation der distalen Gebiete derselben, Virchows Arch. f. path. Anat. **183**:1-54, 1906.

16. Lewaschew, S.: Experimentelle Untersuchungen über die Bedeutung des Nervensystems bei Gefässerkrankungen, Virchows Arch. f. path. Anat. **92**: 152-182, 1883.

17. Grey, E. G., and Carr, Gladys L.: An Experimental Study of the Factors Responsible for Noninfectious Bone Atrophy, Bull. Johns Hopkins Hosp. **26**:381-385, 1915.

18. Allison, N., and Brooks, B.: Bone Atrophy, An Experimental and Clinical Study of the Changes in Bone Which Result from Nonuse, Surg., Gynec. & Obst. **33**:250-260, 1921.

19. Legg, A. T.: The Cause of Atrophy in Joint Disease, Am. J. Orthop. Surg. **6**:84-90, 1908.

tion, the anterior crural nerve was cut, atrophy appeared at the end of the second week. Allison and Brooks sectioned the brachial plexus, and the atrophy again appeared correspondingly early. The amount of atrophy produced by these experiments was directly proportional to the amount of inactivity. The inactivity produced by division of the sensory nerves is slight, but that produced by section of the motor nerves is much more, and hence the atrophy is correspondingly greater.

To determine the significance of blood supply, Grey and Carr ligated the main vessels of both the upper and lower limbs, in dogs, at various levels, but in none were definite trophic changes discernible. Allison and Brooks and Grey and Carr have fixed limbs in plaster-of-Paris. Structural changes occurred at the end of four weeks, and were moderately advanced at the end of eight weeks.

Legg, in 1909, carried out a series of experiments on rabbits. In some instances, he infected the joint cavity; in others, he infected and immobilized it, and, in still others, he simply immobilized it. The immobilization in these cases was carried out with adhesive tape. Legg concluded that the atrophy from immobilization and infection, and from immobilization alone were much greater than from infection alone. From these various experiments, it appears that the atrophy produced is directly due to the inactivity, no matter in what way that inactivity is produced.

Allison and Brooks point out that disuse does not appear to have any effect on the chemical composition of the bones, but that the proportion of water, inorganic and organic salts, are markedly changed even in short periods. In twenty-four days, one-fourth of the mineral constituents of the bone may be lost, and, in 195 days, marked diminution of the thickness of the cortex is seen, but no appreciable difference in the composition of the cortical bone from the sound side. There is less bone matrix rather than a change in the character of the bone matrix, a quantitative rather than a qualitative change. These authors also pointed out that there was a difference in the behavior of animals who had completed growth, and those who had not. In the former, atrophy alone occurred; in the latter, atrophy and inhibited growth. In the fully grown, as a result of atrophy, the cortical bone loses its compact structure, becomes porous, loses its striae, and its diameter changes slightly, the length remaining unchanged. During growth, atrophy causes an alteration in the shape of the bone; it is shorter and thinner, but the diminution is more marked in the shaft than in the extremities, a bulbous appearance being produced at the ends.

The experimental work of Pawlow, Lapinsky and Lewaschew had a different object in view: to produce trophic changes in the extremities. Lewaschew produced neuritis in the sciatic nerve, in dogs, by coating

that nerve with an acid solution over a small part of its course. After eight months, he demonstrated anatomic changes in the vessels, more marked, as a rule, in the distal parts, and assumed that there was a vasomotor disturbance. Lapinsky confirmed the experiments and showed that the more the nerve was injured, the more degeneration and

Fig. 1.—Left hand showing chronic bone atrophy following complete division of brachial plexus and axillary vessels; wide meshes of spongiosa and thickness and strength of individual lamellae may be noted.

vasodilatation was produced. Pawlow produced softening of the bones in dogs, when damp and cold were continually applied to the skin.

The various phases of this experimental work are borne out by clinical work. Gunshot wounds and other severe traumas, involving the

main nerves and vessels to the limbs, have produced the chronic type of bone atrophy, an example of which is seen in Figure 1. In this case, there was a complete section of the brachial plexus and axillary vessels, producing absolute immobilization of the upper limb associated with edema. As regards blood supply, ligation of the main vessels to the limb produces little effect, but if there is an enhanced blood supply to the limb of the growing individual, as in congenital hemangiomas, or congenital arteriovenous aneurysms, the affected limb grows faster, and becomes larger than a normal one; this, in all probability, is due to the greater oxygen content of the venous blood.

CLINICAL MANIFESTATIONS

Acute bone atrophy may occur in any part of the bony skeleton, but it appears to have a special predilection for the extremities and the spine. The lower extremity is by far the most common site of the disease, which is usually limited to the bones of the foot; however, in some cases, the bones of the leg may also be affected. The upper extremity is less often affected than the lower, and the cases have followed more severe trauma than in the leg. In the upper extremity, Colles' fracture has been the most common antecedent of atrophy, which is prone to occur in cases in which the surgeon has not been satisfied with the original reposition, and a second, and, in some cases, a third attempt at reduction has been carried out. The condition, as a rule, is limited to the portions distal to the fracture, but, in some cases, the forearm, elbow, humerus and shoulder joint may be affected. Acute bone atrophy also occurs in the spine, although comparatively rarely. Attention was first called to it by Kümmell, in 1895; he described six cases. Since then, a considerable number have been added to the literature. Two, three or more vertebrae may be affected.

The clinical course of the disease falls into three distinct stages: (1) the initial injury, (2) the latent period, and (3) the period of the fully developed disease. In most cases, the condition is preceded by injury, although in a certain proportion of cases it occurs spontaneously, with no history of injury, however slight, immediately preceding the onset. The most common type of injury, in the lower limb, is a simple sprain, entirely ligamentous, without injury to the bone. It may be a simple twist of the ankle, or a blow on the side of the knee which traumatizes the lateral ligaments; one case followed a dislocation of the patella, which was immediately reduced. In the upper limb, the trauma is more severe, and, in most cases, has been a Colles' fracture, which was difficult to reduce, and there has been probably considerable ligamentous damage. The initial injury to the spine has been classified as a sprain, but, in some of the described cases, there has been an injury to the bony

trabeculae. The trauma, in many of the spinal cases, has been of a very minor nature, so much so that it had almost been forgotten.

The latent period is very definite, but seems to vary considerably according to the site, and is symptomless. It appears to be shortest in the upper extremity, longer in the lower extremity, and longest of all in the case of the spine. In the upper extremity, the condition may set in almost as soon as the initial shock of the injury has passed off, or be delayed, as in one of our cases, for a week. In the lower extremity, it may extend from a few days to two weeks, and, in the case of the spine, the latent period may be from a few weeks to several months. There is no latent period in cases that occur spontaneously.

The clinical manifestations of the fully developed disease vary according to the site of the disease. When this condition complicates a Colles' fracture, the pain at the site of fracture is usually slow in subsiding, the swelling and edema of the hand persist, and the skin becomes glossy and slightly cyanotic. At this stage, the patient generally complains of the pain. The surgeon, thinking he has put the splints on too tightly, readjusts them (it may be on one or two occasions), but finds nothing amiss; both radial and ulnar vessels can be readily palpated. Pain, at this stage, dominates the clinical picture, and the patient is often put down as a neurotic. The finger joints become stiff and painful to passive motion, but the movements of the thumb are, as a rule, maintained, as well as slight motion at the metacarpophalangeal joints. The pain, stiffness, and trophic changes progress for several weeks and then remain stationary unless treatment is instituted.

The changes, in most cases, are distal to the site of the fracture, but, in exceptional cases, all the bones and joints of the arm may be involved. The severity of the lesion is said, by many writers, to have no bearing on the extent of the initial injury, but in one of the cases in this series, in which all the bones and joints of the upper limb were involved, reposition of the fragments was attempted on three occasions.

In the lower limb, the trauma is less severe, and the latent period is longer. After the initial discomfort of the sprain has passed off, pain in the foot slowly develops and increases in intensity until the patient is compelled to take to crutches. Edema and limitation of motion soon appear, and the skin acquires a glazed and bluish-red tint. Both the anterior and posterior tibial vessels can be distinctly felt. There is limitation of motion at both the midtarsal and ankle joints, and the foot slowly acquires a valgoid position. The limitation of motion is due to periarticular changes and muscle spasm. This condition has many features in common with spasmodic flatfoot, and is likely to be mistaken for it. The pain usually disappears following rest, and appears when walking is attempted, or when the legs are dependent. The skin

is hyperesthetic over both foot and ankle; this hyperesthetic area often corresponds to a sock distribution. As in the hand, the condition may progress for several weeks, and then remain stationary for months unless active treatment is instituted.

If trauma is the etiologic factor, the condition is generally unilateral, but, in the spontaneous cases, it is commonly bilateral. Here, again, the condition is generally limited to the portion distal to the site of injury, but if the knee is affected, all the bones taking part in the articulation are affected.

In the spine, the three phases are still better shown, and the latent period is a long one. The trauma may be of such a minor nature that it has long since been forgotten. After a variable period, pain appears in the back at the site of injury, and an angular kyphos slowly appears. If not treated, the pain persists and the kyphos slowly increases in size. Girdle pains arrive, and, later, spastic paralysis sets in from involvement of the spinal cord.

In the limbs, there is always muscle wasting, but this is masked to a certain extent by the edema. In the spine, the wasting is probably equally marked, but not so obvious.

In the lower limbs, acute bone atrophy is a very crippling disease and leads to prolonged incapacity, unless treated early and vigorously. In the spine, the condition is still more serious; owing to the softening of the bones and the superimposed weight of the body, the vertebrae slowly collapse and a kyphos results, which, if not treated, leads to involvement of the spinal cord and to spastic paralysis.

THECRIES ON ETIOLOGY

Four theories have been brought forward to explain the pathologic processes at work in acute bone atrophy.

1. The theory of reflex trophoneurosis attributes the condition to the constant irritation of the sensory nerves transmitting impulses along the afferent channels to the spinal ganglions producing trophic changes in the skin and a disintegration of the bone. It is founded on the work of Julius Wolff, who, in 1877, described trophic changes in the extremities, following gunshot wounds and tuberculosis of joints. Later, in 1883, he explained the disturbance of bone growth as a trophoneurosis not directly through a peripheral nerve injury, but by means of a reflex process. The diminution in size occurred rapidly and simultaneously with the disease, not slowly as in disuse, and, furthermore, the decrease in size remained after the function was resumed.

Sudeck, in his original paper in 1900, asserted that the condition was a low-grade inflammation, but two years later, in 1902, he agreed with Kienböck, who, in the same year, asserted that acute bone atrophy was

essentially a trophoneurosis. These writers believed that the cases of Wolff were merely chronic forms of acute bone atrophy, and the same arguments hold as stated by Wolff. Both Sudeck and Kienböck pointed out that the atrophy of disuse never reaches such intensity as shown in the roentgenograms of acute bone atrophy, with the possible exception of amputation stumps. An analogy has been pointed out between this type of bone atrophy and the rapid wasting of muscle that occurs in connection with infected joints. Paget and Charcot [20] assumed that the early appearance and marked atrophy of muscle was due to reflex action; this idea of reflex action gained experimental proof from the work of Hoffa,[21] who broke the reflex arc in one limb and brought about infection in the joints of this limb as well as in the corresponding limb. Muscle atrophy occurred early, and was very marked on the side where the nerve was left intact, while in the limb where the nerve was severed, there was no atrophy. It has now become an established fact that acute muscle atrophy occurs in a reflex manner. According to this theory, irritation of the sensory nerve is transmitted to the spinal ganglions and causes changes in the normal function which result in atrophy of muscle. In the same way, acute bone atrophy may be explained on a reflex basis; the bone changes appear to occur simultaneously with the muscle changes, and are not secondary to them, nor are they due directly to injury to the peripheral nerves.

Nonne, who made a careful study of bone atrophy in cases of lesions involving the central nervous system with paralysis of the extremities, found instances both with and without bony changes, and he concluded, after a careful roentgenologic study, that bone atrophy only occurred if there were trophic disturbances of the overlying soft tissues, and was due to disturbances in the trophic nerve centers. The experimental work of Nasse [22] and others on nerve section and nerve irritation has clearly shown that simple division of a nerve does not produce acute atrophy, but, in complete division producing a constant irritation, gives rise to trophic changes.

The work of Schubert [23] in relation to bone growth and bone atrophy has shown that bone atrophy is due to the constant stimulation of the different nerve endings in the neighborhood of an inflamed joint. This

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20. Paget and Charcot, quoted by Shaffer, N. M.: Selected Essays on Orthopedic Surgery, New York, G. P. Putnam's Sons, 1923, pp. 11-12.

21. Hoffa, A.: Zur Pathogenese der arthritischen Muskelatrophein, Samml. klin. Vortr. **1**:275-286, 1892.

22. Nasse, H.: Ueber den Einfluss der Nervendurchschneidung auf die Ernährung, insbesondere auf die Form und die Zusammensetzung der Knochen, Arch. f. Physiol. **23**:361-405, 1880.

23. Schubert, A.: Wachstumsunterschiede und atrophische Vorgänge am Skelettsystem, Deutsch. Ztschr. f. Chir. **161**:80-123 (Feb.) 1921.

stimulation acts reflexly on the efferent nerve fibers to the vessels in the neighborhood of the epiphyses. He found that the growth centers were interfered with in the adolescent period, and produced changes in size; in the adult, simple bone atrophy occurred. He believed that those cases of acute bone atrophy were brought about by vascular changes through reflex channels.

More recently, Turner studied acute bone atrophy as one of the rarer complications of Colles' fracture. He also cites six cases of cat bite which preceded typical acute bone atrophy. He believes that nerve injuries in fractures are frequently overlooked, and that, in the cases in which acute bone atrophy complicates Colles' fractures, the sharp fragments of the radius irritate the dorsal interosseous nerve, and sometimes the styloid process of the ulna irritates the dorsal cutaneous branch of the ulnar nerve. The cat bite cases fall into the same category, the sharp teeth of the cat traumatizing the dorsal interosseous nerve. In both cases, the syndrome is due to nerve irritation. He believes trauma to be the primary cause, while irritation of the dorsal interosseous nerve acts through a reflex channel, and produces a trophoneurotic change. This explanation is substantiated by a case in which the irritated nerve was sectioned higher up, and rapid improvement was observed.

To sum up this theory, acute bone atrophy is reflex trophoneurotic in origin, a disturbance in the metabolism of the bones being produced, so that the bone substance is broken down more rapidly than it can be reconstructed.

2. Hilgenreiner is the main advocate of the theory of inactivity, and his conclusions are drawn chiefly from a study of gunshot wounds. He believes that the chief etiologic factor is disuse, that the intensity of the atrophy is due to the individual disposition of the patient, and that the atrophy occurring distal to the injury results from ischemia. He also points out that function is regained more rapidly than the normal structure of the tissues, but that the functional result is not complete until the atrophy has entirely disappeared. Hilgenreiner believes that the pain is an important causative factor of the atrophy, for if pain is present all motion is lost, although Sudeck, in his trophoneurotic theory, believes pain is secondary to the atrophy.

The peculiarities of bone atrophy described by Cohn are, according to Hilgenreiner, entirely the result of disuse; thus, the atrophy occurring in one instance and not in another is explained by the variation in the amount of disuse resulting from different types of injuries, and further there is an individual variation in the calcium content of the skeleton. The amount of atrophy and the time of appearance will necessarily vary in different parts of the body, depending on the normal mobility of the

part. The greater the normal mobility, the earlier and more marked will be the appearance of the atrophy. The fact that only the fractured bone atrophies, when two bones lie side by side, is also explained by this theory on the grounds of disuse; thus, when the radius is fractured, the active motion of the ulna is not discontinued, and, consequently, the radius atrophies, while the ulna, because of increased function, may display an even greater density than normal. The involvement of the central fragment as well as the distal one in joint injuries, such as in the knee, is also explained by inactivity, the whole joint being held at rest. The studies of Nonne on paralyzed extremities due to nerve lesions are also explained on the basis of inactivity, but, in cases of hysteria without atrophy, Hilgenreiner believes the passive motion is sufficient to prevent its appearance.

In the experimental work already quoted, the chronic atrophy corresponds to the degree and length of time of fixation, and the distal bones show the atrophy first. Interesting and suggestive work has been done by Anzoletti [24] on the association of inactivity and bone atrophy in rickets. This writer put a rachitic limb in a plaster-of-Paris cast, and after several weeks of immobilization, the plaster-of-Paris cast was removed, when the bones were found to be soft, and could be easily molded into the desired shape.

According to this theory, the primary etiologic factor is disuse, but its advocates are also willing to admit that nerve injuries producing vascular changes and infection also play a part. The latter factors are covered by the term "ischemia."

3. At present, the theory of infection has very few advocates. It was originally put forward by Sudeck, but he soon set it aside for the trophoneurotic theory. According to the infection theory, an inflammation around the primary injury spreads over an extensive area and brings about an atrophy due to a disturbance of the nutritional supply; those cases in which the injury is associated with an open wound, and in which a certain amount of inflammatory reaction follows, would be more easily explained by such a theory than those in which there is no open wound. In the latter, one would have to assume a focus of infection in some other part of the body. In favor of this theory is the fact that the so-called inflammation spreads over a wide area, and that there is no difficulty in demonstrating periarticular inflammation. The early appearance of pain on motion of the joints, the difficulty, and frequently the impossibility, of maintaining movements of the joints are all in favor of inflammation of the bone, and most probably of the bone marrow. On the other hand, it must be admitted that an actual inflammatory

24. Anzoletti, quoted by Hilgenreiner (Footnote 9, second reference).

lesion has never been demonstrated in the bone marrow, either microscopically or bacteriologically.

The theory would have to rest on a low-grade inflammation of the bone marrow which, in some manner, interferes with the nutritional supply of the bone, or leads to destruction of the substance of the bone.

4. Cohn,[25] not satisfied with any of the three foregoing theories, formulated one of his own. He, like previous writers, could not find a satisfactory explanation for the facts that: (1) acute bone atrophy occurs in some cases, and not in others, when the original cause in both cases appears to be the same; (2) when two bones are lying side by side, one fractured and the other not, the fractured bone only shows the atrophy, and (3) in some cases when a joint is involved, the atrophy proceeds in both directions. Cohn attempts to explain these facts as the result of a third type of bone formation, quite distinct from the endosteal and periosteal types. His observations show that there is a definite relationship between bone atrophy and bone regeneration. Apparently, the calcium is carried by the lymph vessels and deposited in soft tissues where there is a deficiency of carbon dioxid in the blood. The roentgen rays, according to Cohn, disclose shadows of the calcium in the soft tissues in cases in which this third type of bone regeneration is playing an extensive part. There is a reason for the production of the atrophy in that there is a demand created for calcium. In one case, the endosteal and periosteal regeneration are sufficient; in another case, these are insufficient, and the third type of bone formation is called into play. Thus, we see a loss of calcium in the distal part of the extremities. The roentgen rays show shadows of calcium in the soft tissues on their way to the site of the original trouble. The lymph stream flows toward the body; thus, the calcium must be taken from the distal part. He has noted that there is a greater degree of atrophy in some types of disease than in others, and that the less the injury to the periosteum, the greater is the demand for the regeneration of bone by the third method, and, consequently the greater is the atrophy present.

The explanation of acute bone atrophy would thus be that it is a product of this third method of bone formation. The necessary calcium salts are taken from the distal part of the skeleton by means of the lymph stream to an area of disease or injury. The pain results from the increased amount of calcium in the soft tissues.

The only theory that appears to explain satisfactorily all the pathologic processes in acute bone atrophy is the trophoneurotic theory. Physiologists, up to the present time, have been unable to demonstrate

25. Cohn, M.: Ueber die Beziehung zwischen Knochenatrophie und Knochenregeneration auf dem Wege der Kalkwanderung, Arch. f. klin. Chir. **112**: 231-246, 1919.

trophic nerves in the limbs, although they have been demonstrated in the heart and intestine. The experiments recently carried out by Pawlow, by which he produced softening of the bones in dogs by continuous application of damp and cold to the extremities, are analogous to the cases of acute bone atrophy. It seems probable, then, that the symptoms and signs of acute bone atrophy are explicable by a reflex irritation and stimulation of the trophic nerves, producing an increased metabolism in the tissues.

ANALYSIS OF CASES

During the twelve years, 1912 to 1924, forty-eight cases of acute bone atrophy have been recorded in the Mayo Clinic. Forty-one of these were in the lower limbs, six in the upper limbs, and one in the spine.

Of the forty-one cases in the lower limbs, twenty were in males and twenty-one in females. The ages varied considerably, the youngest patient being 19, and the oldest about 64. Eighteen of the forty-one cases occurred in the decade from 40 to 50, showing that this disease commonly occurs in middle life. The exciting factors can be grouped under three headings: (1) minor trauma (twenty-seven cases), (2) unknown etiology or spontaneous (twelve cases), and (3) fracture of both bones of the leg (two cases). The minor traumas were, in most cases, sprains, but, in a few cases, the injury was a direct one of a minor nature with no injury to the bone. One of the cases of fracture was of the internal malleolus, and the other of both bones of the leg in its lower third. Five of the cases were bilateral, and thirty-six were unilateral. The sides and regions affected were: left foot, fourteen cases; right foot, fourteen cases; left knee, three cases; right knee, five cases, and both feet, five cases. Of the bilateral cases, four were spontaneous, but, in one case, a minor trauma was the exciting factor on one side, and, three months later, the disease appeared spontaneously on the other side. In five cases, there were complications: septic teeth and tonsils, phlebitis, typhoid fever, cystitis, and adenoma of the thyroid. The Wassermann reaction was negative in all cases.

The interval between the trauma and the onset of symptoms of acute bone atrophy was as follows in the cases of minor trauma: one-half day, two cases; one day, six; two days, five; seven days, eleven, and fourteen days, three. In the two cases of fracture, the initial symptoms seem to have passed imperceptibly into those of acute bone atrophy.

Of the six cases which occurred in the upper limb, five were a complication of Colles' fracture, and one followed a manipulation of the shoulder further complicated by a traumatic neuritis of the ulnar nerve. It is difficult to estimate the frequency of this complication, as the five

cases occurred in a series of 136 cases of Colles' fracture, the patients having come to the clinic because of dissatisfaction with the late results of treatment of the fracture elsewhere. Five of the six patients were women. The youngest was 38, and the oldest 69, giving an average age of 46 years. The average time elapsing between the receipt of trauma and the examination was three and one-half months. In four cases, the condition was in the right arm, and, in two, in the left.

The interval in all these cases is a short one, probably from two to three days, for, as the initial discomfort of the trauma was passing off, the symptoms of acute bone atrophy seemed to set in.

We have observed only one case of atrophy of the spine. This occurred in a man, aged 42, eight weeks after direct trauma to the back.

ROENTGENOLOGIC FINDINGS

The roentgenologic findings are definite and distinct, and can be divided into two phases: the acute and the chronic. The acute phase passes through the chronic one on the way to recovery, but occasionally one finds the condition has passed into the chronic phase before the patient comes for treatment.

The striking feature about this form of atrophy is the great predilection it has for the extremities, especially for the distal portions. Sudeck explains this as due to the fact that the roentgen ray will show lesions earlier in small bones than in larger ones. Bone atrophy is often missed in reading a roentgenogram because there is no alteration in the form, only a diminution in density; this is more easily noticed if compared with a roentgenogram of the sound limb. The lesion is almost invariably distal to the site of the injury, and the more distal the bones are, the greater the atrophy. The changes in the distal row of the carpus are more marked than those in the proximal row, and if the trauma is to a joint, such as the knee, all the bones which take part in the formation of the joint show the atrophy.

The time of onset of the acute stage varies, and seems to depend on the site and the type of the original trouble. The roentgen-ray appearances of the acute stage are characterized by perforations in the spongiosa, producing irregular openings of various sizes. The lamellae are no longer clear-cut, but fade into one another and produce a poorly defined shadow. This usually shows itself from four to six weeks after the original etiologic factor has manifested itself, but the changes have been going on long before they can be demonstrated by the roentgen rays. There are scattered, irregular, rarefied areas, like small, punched-out holes, in the spongiosa of the distal joints and heads of the metacarpals or metatarsals, as the case may be.

In the chronic phase, the pallor is greater than in the acute phase. The rarefied areas have disappeared; the spongiosa is widely meshed, and the individual lamellae are thicker and stronger, but this increased strength is only in the longitudinal fibers, the horizontal ones remaining thin. If the atrophy continues, the remnants of the spongiosa may be lost, giving an equal illumination, like a pane of glass.

Fig. 2 (Case 1).—Impacted Colles' fracture, showing acute bone atrophy.

PROGNOSIS AND TREATMENT

The end-results of sprains of the ankle and Colles' fracture are so uniformly good that there is nothing to be said in the way of prevention of bone atrophy.

The tendency is for acute bone atrophy to run its course, and the results of efficient treatment are practically always satisfactory, but the

convalescence is long, from six months to two years. Treatment consists of heat to the point of tolerance, either in the form of radiant heat or paraffin baths. Massage and voluntary motion of the joints should be persisted in, in spite of a little pain. Voluntary motion is of infinitely more value than passive motion. Any form of fixation, such as braces and plaster-of-Paris casts, are contraindicated; equally detrimental are forcible manipulations under anesthesia which only cause further irrita-

Fig. 3 (Case 2).—Ankle showing acute bone atrophy.

tion and more atrophy. In three of our cases, incisions had been made into the edematous area, because pus was suspected; no improvement followed.

REPORT OF CASES

Case 1.—A woman, aged 51, sustained a Colles' fracture, Jan. 18, 1924. The fracture was reduced and put in splints for three weeks, during which time she was quite comfortable. At the end of three weeks, a roentgen-ray examination of the arm was made, and the home doctor, not satisfied with the position, manipulated it. After this manipulation, the wrist and hand became edematous,

and the fingers gradually became stiff and painful to move. The pain and stiffness persisted until the patient came to the clinic, April 17. Our examination revealed trophic changes with edema over the hand and wrist, and marked wasting of the muscles of the forearm. Only a few degrees of voluntary motion of the fingers were present, and passive motion was very painful. Roentgenograms revealed an impacted Colles' fracture with separation of the tip of the ulna, and acute bone atrophy distal to the point of fracture. The Wassermann

Fig. 4 (Case 2).—Right foot showing acute bone atrophy.

reaction was negative, and other examinations disclosed nothing abnormal. Treatment with heat, massage and voluntary movements was instituted, and, at the end of four weeks, the patient left the clinic distinctly improved (Fig. 2).

Case 2.—A merchant, aged 42, came to the clinic, Feb. 20, 1924, complaining of swelling of the right foot and inability to walk. He had accidentally twisted his left foot inward, Dec. 18, 1923. A slight degree of swelling had occurred

at the time, and a tight bandage had been applied. Six days later, an elastic bandage was applied, and he went to work. Eleven days after the original accident, swelling appeared in the ankle and foot, and spread upward to the knee. Pain developed in the foot and leg. The patient was forced to remain at home, being unable, even with crutches, to get to work. A period of rest and elevation resulted in a decrease in the swelling, but, following any attempt to use the limb, the swelling and pain returned.

When examined at the clinic, the patient was well developed and well nourished; he got about with difficulty on crutches. The swelling extended up to the knee; the skin was cyanotic and glossy, and pitted on pressure. Both anterior and posterior tibial vessels were distinctly felt. Motion in the midtarsal and ankle joints was limited by muscle spasm, and there was considerable pain on passive motion. Roentgenograms revealed marked bone atrophy, but no fracture (Figs. 3 and 4). The Wassermann reaction was negative. The treatment consisted of rest, elevation, baking, massage and voluntary movement, and, at the end of two weeks, there was very definite improvement.

Fig. 5 (Case 4).—Edema, with trophic changes of seven weeks' duration, posterior and anterior views.

CASE 3.—A man, aged 32, came to the clinic, June 14, 1924, complaining of pain in the feet and inability to walk. The pain had commenced on the dorsum of the left foot six years before, and occurred on rising on the toes. Once started, it came with every step. Soon after the onset of pain in the left foot, pain of a similar nature developed in the right foot. The pain and discomfort gradually increased in intensity, until it occurred the moment any weight was put on either foot and was further aggravated by walking. The patient gradually acquired a "Charlie Chaplin" gait to reduce his suffering to a minimum. The pain was dull in character, and was compared by the patient to that occurring in a quick, forced hyperextension of a finger at the metacarpophalangeal joint. The pain was not spontaneous; it only occurred on motion or weight bearing.

Examination revealed edema and cyanosis of the feet and ankles, and extending halfway up the legs. The skin was glossy in appearance, and showed evidence of trophic changes. There was hyperesthesia half-way up the legs. The feet were held in a valgoid position, and any attempt at motion at the midtarsal or ankle joints was resisted by muscle spasm. The Wassermann

reaction was negative. Roentgenograms did not reveal fracture, but marked acute bone atrophy. The treatment consisted of rest, elevation, baking, massage and voluntary movements. The patient did not wait for treatment at the clinic.

Case 4.—A man, aged 48, came to the clinic, Oct. 28, 1924, complaining of stiffness of the right hand. Seven weeks before, he had sprained the right wrist while using a saw; he continued with his duties for three or four days,

Fig. 6 (Case 4).—Right hand showing acute bone atrophy following sprain.

when he struck the same hand against a door. He again continued his work, but had to give it up, three or four days later, because of pain.

Examination disclosed edema with trophic changes of the wrist and fingers (Fig. 5). The wrist and finger joints were stiff and painful when moved. Roentgenologic examination revealed acute bone atrophy, but no fracture (Fig. 6). The treatment which is being carried out consists of a short cockup splint, heat, massage and active movements.

CONCLUSIONS

1. Acute bone atrophy is a definite clinical entity. It has a typical history and clinical picture, as well as characteristic roentgenologic findings.

2. Acute bone atrophy may occur spontaneously or may follow a minor trauma. It is an occasional complication of Colles' fracture. Kümmel's disease is only an example of this disease.

3. Acute bone atrophy is best explained on the basis of reflex trophoneurotic action.

4. Early and vigorous treatment will prevent permanent disabilities, and shorten the course of the disease.

THE RECURRENT LARYNGEAL NERVES IN DOGS

EXPERIMENTAL STUDIES *

ALFRED BLALOCK, M.D.
NASHVILLE, TENN.
AND
S. J. CROWE, M.D.
BALTIMORE

The recurrent laryngeal nerve is in many respects ideal for the study of nerve regeneration, either spontaneous or that which occurs after suture. The intrinsic muscles of the larynx are supplied by the recurrent and the superior laryngeal nerves, and in the anesthetized dog any change in the involuntary movements of the vocal cords that may result from experimental lesions to either or both of these nerves may be observed by direct inspection through the mouth. The recurrent nerves in the dog are easily accessible and may be anastomosed to the vagus, the phrenic, the descending hypoglossal or to any one of the branches from the cervical plexus. If the involuntary and rhythmic respiratory movements of the vocal cords are dependent on the central connections of the recurrent and superior laryngeal nerves, experimental proof of this fact might be obtained by division of these nerves in the neck and the anastomosis of the peripheral end to a branch from the cervical plexus. We have made no careful observations on this point. Motion pictures of the vocal cords before and after such an anastomosis might be necessary to afford convincing proof. Although it is easy to watch from day to day the movements of the vocal cords in the dog, it is difficult to interpret these observations with accuracy; such data should be used to supplement the more objective results of stimulation of the nerve trunk both proximal and distal to the anastomosis, and the various histologic evidences of regeneration.

Any new facts in regard to the mechanism that moves the vocal cords are of interest not only from a physiologic point of view but also because they may be of aid in the recognition and treatment of clinical conditions. The muscles that adduct and abduct the vocal cords are supplied by the recurrent nerve on that side; there is no evidence of a crossed innervation of these muscles. In 1881, Semon [1] postulated the law that the first evidence of an organic lesion of the recurrent laryngeal nerve in man is a limitation or absence of abduction; as the lesion pro-

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* From the Department of Surgery of the Johns Hopkins University Medical Department.

1. Semon, Felix: Arch. Laryngol. **2**:197, 1881.

gresses the adductor muscles are paralyzed and the vocal cords become motionless. It has long been observed that tension on a recurrent laryngeal nerve either as a result of a surgical operation on the thyroid, a slowly developing aneurysm of the aorta or innominate, or the neuritis that is sometimes associated with tabes, will produce changes in the movements of the vocal cords in accordance with Semon's law. A satisfactory explanation, however, for this peculiar vulnerability of the abductor fibers has never been advanced. It has been suggested that the fibers that supply the abductor muscles are situated near the periphery of the nerve trunk and are therefore more exposed to stretching or pressure. Our histologic studies [2] of recurrent nerves removed at necropsy from patients who had clinical evidence of impaired motility of a vocal cord as a result of local pressure or stretching of the nerve fail to show any definite zone in which the degenerated fibers lie, and the experimental studies on regeneration presented in the illustrations of this article show that the new fibers appear at random throughout the nerve.

It is fortunate that organic disease of the recurrent nerve manifests itself at an early stage by a paralysis of only one set of muscles. This offers an opportunity for recognition and possibly surgical intervention before the process has become complete. A case of beginning paralysis (probably central in origin) in which a good functional result was obtained by anastomosing the cut end of the descending noni to the side of the recurrent laryngeal nerve has been reported by Frazier. [3]

The experimental work presented in this paper affords both physiologic and histologic evidence of regeneration following an anastomosis of the recurrent laryngeal to the following nerves: (*a*) the upper root of the phrenic (end to end); (*b*) the phrenic (end to side); (*c*) the vagus (end to side), and (*d*) the descending hypoglossal (end to end).

METHOD

The nerves were handled as little as possible. Very fine silk (China-beaded) was used in all anastomoses. In almost every instance, only one suture was employed and this was not tied tightly. An effort was made to pass the suture only through the epineural sheath. When the end to side type of anastomosis was used, a longitudinal slit was made in the intact nerve and the distal end of the cut recurrent laryngeal was pulled into the opening and anchored with silk. Tension on the suture line could be avoided in every case. In several animals, the superior

2. Observations by us on the effect of pressure on the recurrent laryngeal nerve, unpublished.

3. Frazier, C. H.: Anastomosis of Recurrent Laryngeal Nerve with Descendens Noni in Cases of Recurrent Laryngeal Paralysis, J. A. M. A. **83**: 1637 (Nov. 22) 1924.

laryngeal nerve on the same side as the anastomosis was divided and about 1 inch (2.5 cm.) of it was resected. In some instances, this was done at the time that the recurrent was anastomosed; in others it was done at a later date in order to observe the effect of this procedure on the returning movement of the cord.

The wound was closed by approximating the muscles, fascia and skin with silk, and always without drainage. The vocal cords were observed at the completion of the operation and at frequent intervals between the time of operation and the date on which the animal was killed. Morphin and light ether anesthesia were used whenever an observation was made.

The anastomosed nerves were stimulated with an induced current using a bipolar electrode, and the vocal cords were observed at the same time. The strength of the current was not measured but was roughly approximated by placing the electrodes on the observer's hand.

When the animals were sacrificed material for histologic study was taken from:

(*a*) The site of the anastomosis with about 1.5 cm. of nerve on each side. In some instances, a Bielchowsky stain was made after the nerves were sectioned longitudinally, while in others the Cajal technic was used in staining the nerve before embedding. A modification of the Bielchowsky stain by Miss Helenore Campbell of the Army Medical Museum was employed in several cases. Good preparations are difficult to obtain because of the small diameter of the nerves and the ever present uncertainty of silver staining methods.

(*b*) A portion of the recurrent nerve distal to the anastomosis and very close to the larynx was taken in nearly all of the experiments and stained by the Weigert method for myelin. In several instances a similar section was placed in Bensley's fluid and stained with Mallory's phosphotungstic acid hematoxylin.

(*c*) Pieces of the nerve distal to the anastomosis were stained with hematoxylin and eosin for the nuerilemmal nuclei.

(*d*) The larynx was removed in toto in all cases and cross sections made to study the changes that might occur in the cords and intrinsic muscles.

PROTOCOLS OF EXPERIMENTS

I. ANASTOMOSIS OF THE RECURRENT LARYNGEAL NERVE TO THE UPPER ROOT OF THE PHRENIC (FROM THE THIRD CERVICAL NERVE)

EXPERIMENT 1.—In Animal 1, anastomosis was made on the left side, Oct. 11, 1924. There was complete paralysis of the left cord at the completion of the operation. The cords were observed at frequent intervals subsequently with the animal under ether anesthesia. The first definite movement was detected three and one-half months following the original operation, but the excursion

was never as great as that on the opposite side. Six weeks later, about 1 inch (2.5 cm.) of the superior laryngeal nerve on the left was resected but without affecting the movement of the left cord. The anastomotic site was then exposed and stimulated and the left cord responded with a definite abduction. The animal was killed, March 27, and tissues were taken for study.

The vocal cords did not show any atrophy. A section of the recurrent nerve distal to the anastomosis when stained with phosphotungstic hematoxylin showed definite myelinization but not as complete as that seen in the opposite sound nerve. A Cajal silver stain of the recurrent nerve distal to the

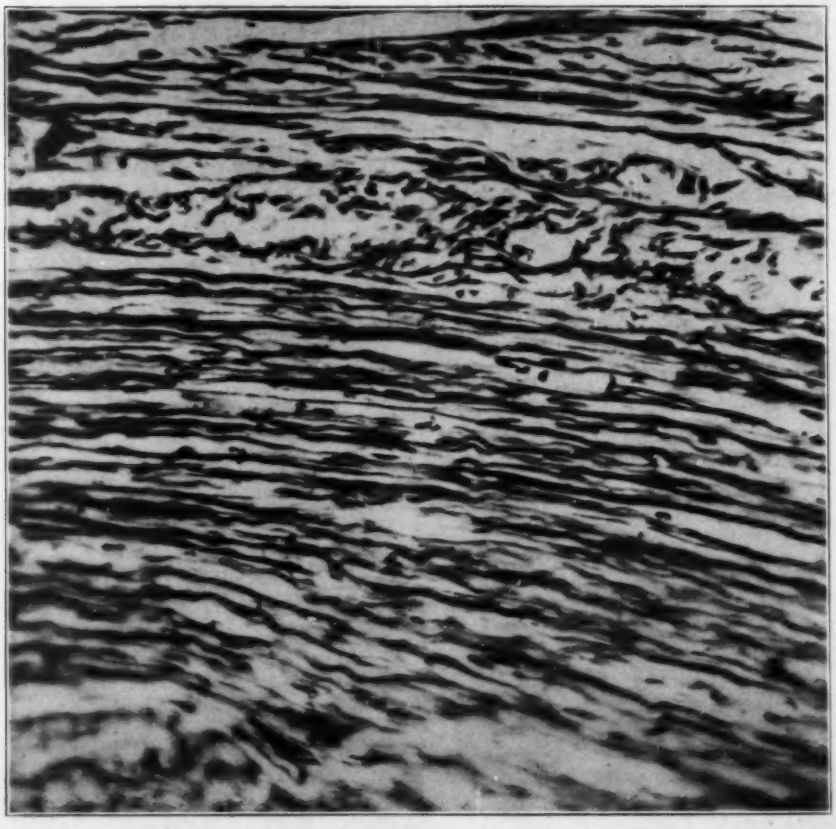

Fig. 1 (Experiment 3).—Longitudinal section distal to recurrent laryngeal and upper root of phrenic nerve anastomosis removed ten weeks after operation, illustrating axis cylinders (× 500); Bielchowsky stain.

anastomosis showed regenerated axis cylinders. A cross section of the recurrent distal to the anastomosis showed many more neurilemmal nuclei than the opposite sound nerve.

EXPERIMENT 2.—Animal 2 died of pneumonia ten weeks following the operation. No histologic studies were made on the nerves and the cords were not observed immediately prior to death. A note made six weeks following the operation stated that the cord on the affected side moved slightly. Both vocal

cords looked normal at necropsy. There was no apparent atrophy of the diaphragm.

EXPERIMENT 3.—In Animal 5, anastomosis was made on the left side between the upper root of the phrenic and the recurrent nerve, Oct. 29, 1924. A very evident movement of the left cord was noted eight weeks after the operation. The excursion was not nearly as great as that on the normal side. Jan. 6, 1925, both superior laryngeal nerves were divided and about 1 inch (2.5 cm.) resected. The central end of the descending hypoglossal and the distal end of the right recurrent were then anastomosed.

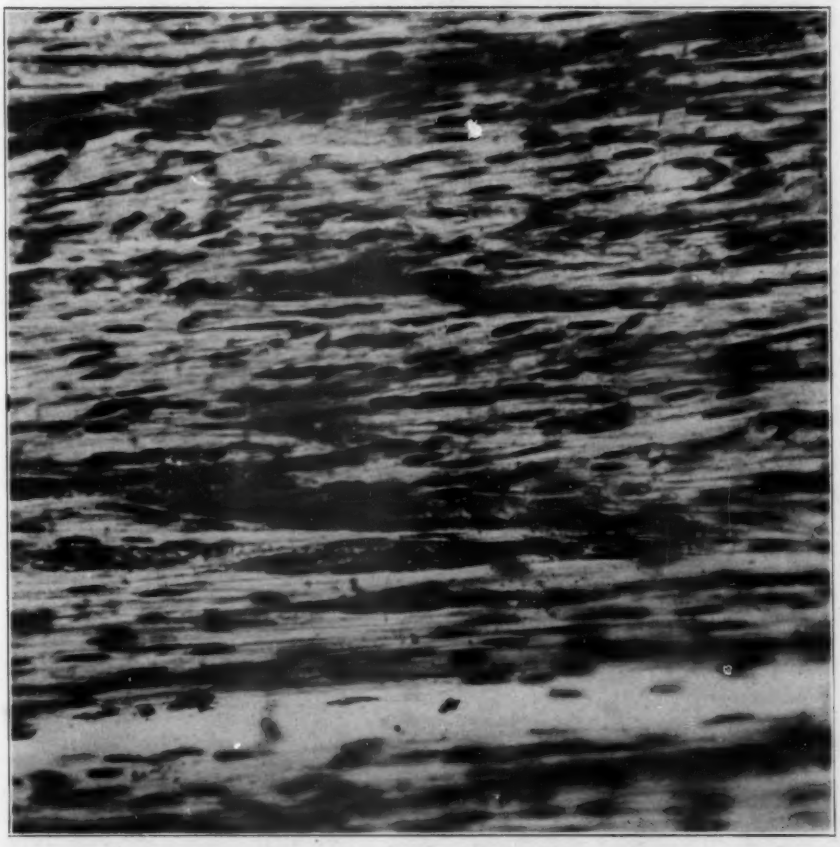

Fig. 2 (Experiment 3).—Longitudinal section at site of recurrent laryngeal and upper root of phrenic nerve anastomosis at tenth week, demonstrating hyperplasia of neurilemmal nuclei (× 500); hematoxylin and eosin.

Observation at the completion of this operation showed complete paralysis on the right side and definite movement on the left. One week after the second operation, complete paralysis on the right side and movement on the left were again observed. The animal was having much respiratory distress at this time and died three days later. No pneumonia was found at necropsy, and death was thought to be due to the respiratory obstruction. In spite of the fact that

the left cord was completely paralyzed, the returning motion of the left cord, which at this time was limited to adduction, caused respiratory stridor.

Sections of the vocal cords show slight edema. With a Bielchowsky stain axis cylinders could be traced through the anastomosis on the left side (Fig. 1).

There was an increase in the neurilemmal nuclei at the site of the anastomosis on the left (Fig. 2). A Weigert stain distal to the anastomosis showed a few myelin rings. A silver stain of the distal end of the right recurrent showed that the degeneration of the axis cylinders was not quite complete as the interval between the operation and death was only ten days.

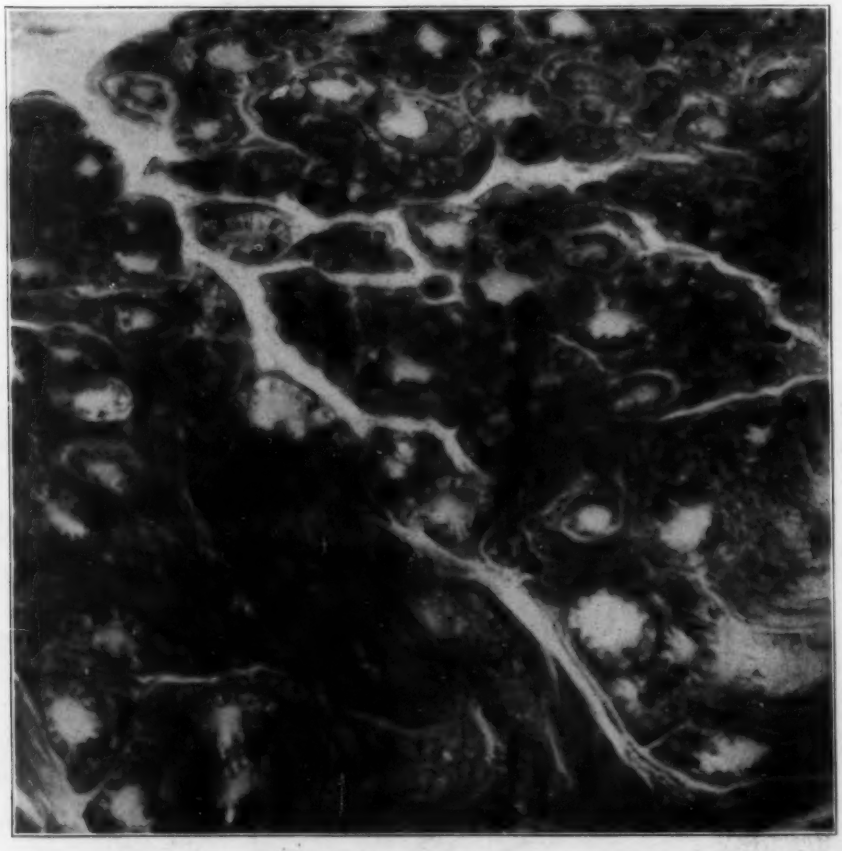

Fig. 3 (Experiment 4).—Cross section distal to anastomosis of severed recurrent nerve to side of phrenic nerve at eighteenth week, showing myelin rings (× 1,200); Weigert stain.

In three animals the recurrent nerve was divided and anastomosed to the upper root of the phrenic on the same side. Owing to delay in making a postmortem examination, the tissues in one animal were not suitable for histologic study. In the two remaining animals, a return of function was indicated by observation of the involuntary movements of the vocal cords, of the movement of the cord on the side of the

anastomosis when the recurrent nerve was exposed and was stimulated both central and peripheral to the anastomosis, and finally by the microscopic sections stained for axis cylinders, myelin sheaths and neurilemmal nuclei.

II. ANASTOMOSIS OF THE DISTAL END OF THE DIVIDED RECURRENT LARYNGEAL NERVE INTO A LONGITUDINAL SLIT IN THE MAIN TRUNK OF THE PHRENIC NERVE

EXPERIMENT 4.—In Animal 3, the recurrent nerve on the left was divided about 3 inches (7.6 cm.) below the larynx and the peripheral end implanted into the side of the phrenic, Oct. 18, 1924. The first definite return of movement was observed fourteen weeks after the operation. March 3, 1925, the superior

Fig. 4 (Experiment 5).—Cross section distal to the anastomosis of severed recurrent nerve to side of phrenic nerve, showing axis cylinders at eighteen weeks (×2,000); Cajal method.

laryngeal nerve was cut on the left side: this had no effect on the movement of the left cord. The nerve was then exposed and stimulated distal to the anastomosis, and marked movement (abduction) was observed. A Weigert stain of the recurrent distal to the anastomosis showed well formed myelin sheaths (Fig. 3). A silver stain of the recurrent distal to the anastomosis showed regenerated axis cylinders (Fig. 4). The diaphragm on the left side looked normal microscopically and macroscopically.

EXPERIMENT 5.—In Animal 4, the right recurrent nerve was divided and implanted into the side of the phrenic, Oct. 21, 1924. Definite movement was observed ten weeks after the operation. Two weeks later, the superior laryngeal

nerve was cut on the right side without affecting the movement of the right cord. The nerve was not stimulated electrically. The animal was killed and no atrophy of the vocal cord or diaphragm on the right was found.

A silver stain of the recurrent nerve distal to the anastomosis showed regenerated axis cylinders, and a Weigert stain showed a few myelin rings.

EXPERIMENT 6.—In Animal 6, an operation was performed on the left side, Oct. 28, 1924. Definite movement was observed eight weeks following the

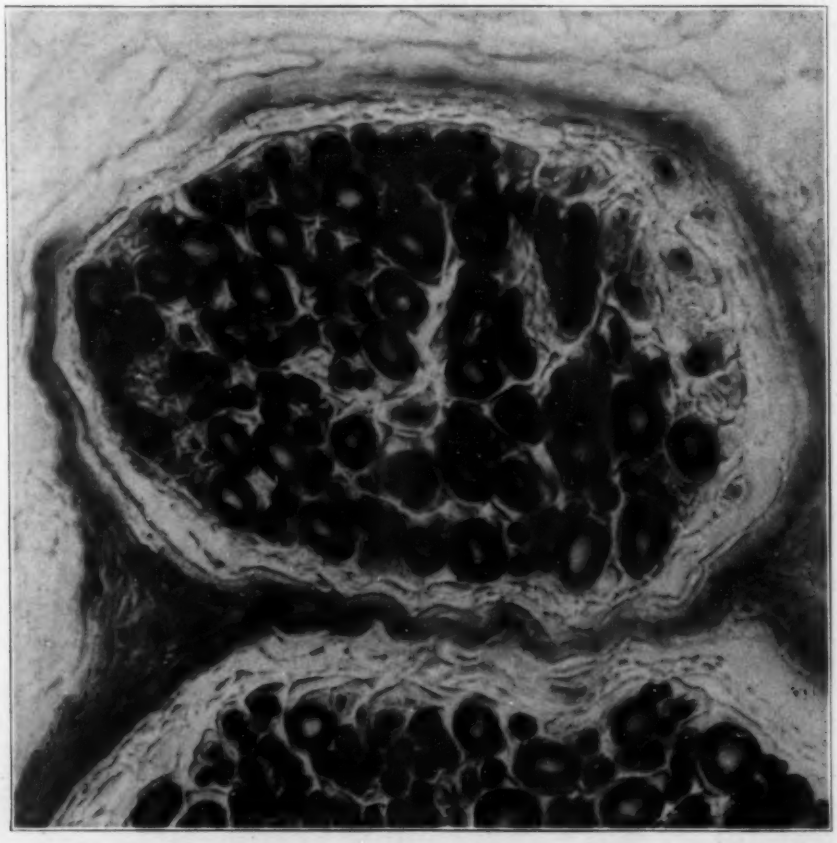

Fig. 5 (Experiment 7).—Cross section distal to anastomosis of recurrent laryngeal nerve to side of vagus nerve at three months, illustrating rings of myelin (× 1,200); Weigert stain.

operation. The superior laryngeal nerve was cut on the same side, Jan. 21, 1925, and the cord continued to move as before. The animal was then sacrificed and the cords and nerves taken for study. The vocal cords looked normal on gross examination.

Microscopic sections of the recurrent nerve distal to the anastomosis showed a few myelin rings. A great increase in the number of nuerilemmal nuclei were seen at the anastomotic site.

Three experiments were performed in this group. Each of these showed evidence of regeneration. A return of function to the paralyzed cord was indicated by direct observation both with and without stimulation. Histologic evidence of regeneration was evidenced by stains showing axis cylinders, myelin sheaths, and increase in neurilemmal nuclei.

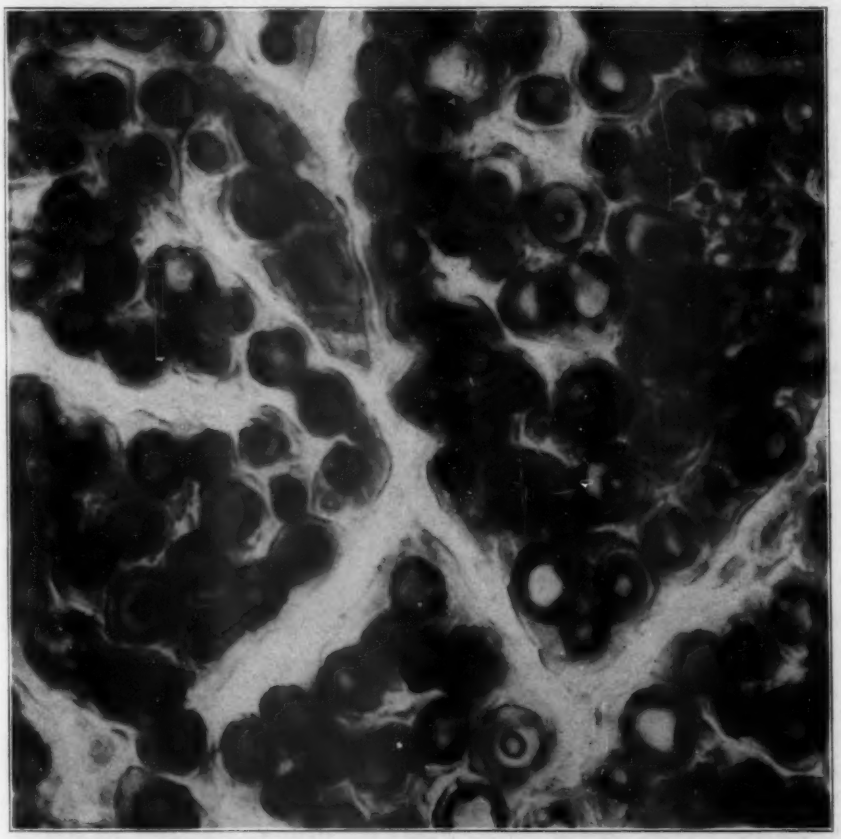

Fig. 6 (Experiment 8).—Cross section distal to anastomosis of recurrent laryngeal nerve to side of vagus nerve at fourteen weeks, illustrating rings of myelin (× 1,200).

III. ANASTOMOSIS OF THE DISTAL END OF THE DIVIDED RECURRENT LARYNGEAL TO A LONGITUDINAL SLIT IN THE VAGUS

EXPERIMENT 7.—An operation was performed on the left side on Animal 7, Nov. 1, 1924. Definite movement was observed eight weeks after the operation. The dog died from the anesthetic, Feb. 3, 1925, before an attempt to stimulate the nerve could be made. An observation before the operation showed definite movement of the cord but the excursion was limited.

The vocal cords looked normal grossly. A Weigert stain of the distal recurrent laryngeal showed well formed myelin rings (Fig. 5). The silver stain was a failure.

EXPERIMENT 8.—An operation was performed on the right side on Animal 12, Nov. 25, 1924. Definite movement of the right cord was observed after nine weeks. The nerve distal to the anastomosis was stimulated directly, March 16, 1925, and the right cord was observed to move very definitely. The animal was then killed.

The vocal cords looked normal grossly. A section of the recurrent laryngeal nerve far distal to the anastomosis showed normal myelin rings (Fig. 6).

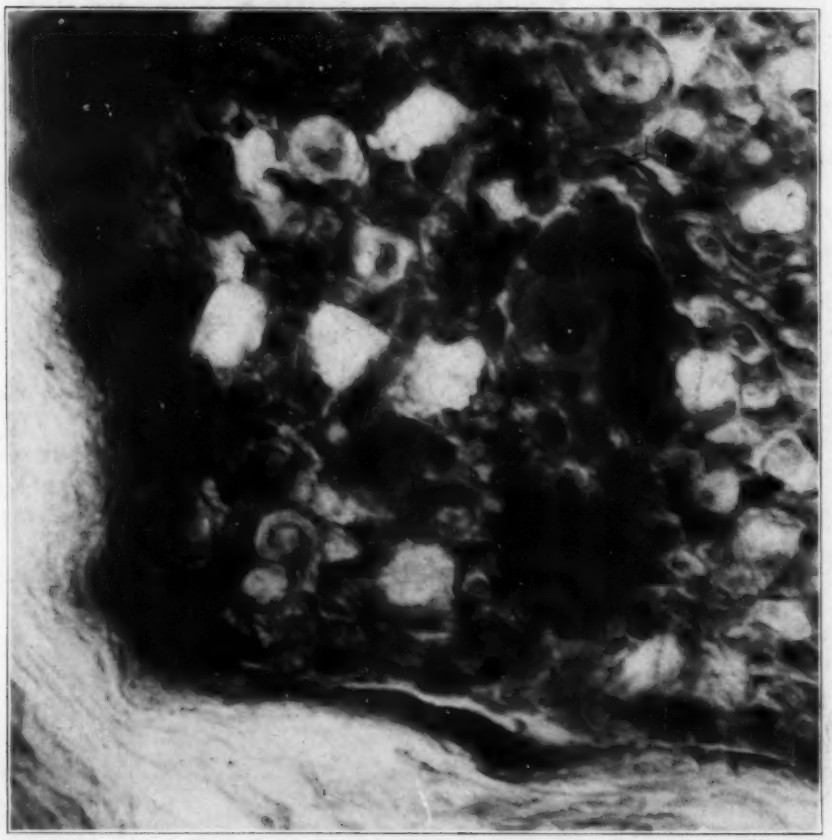

Fig. 7 (Experiment 10).—Cross section of distal recurrent laryngeal nerve twenty-six days after it was placed in a slit in the opposite sound nerve, demonstrating a few myelin rings (× 1,200); Weigert stain.

Two experiments were performed in this group. A return of function was evidenced by movement with and without stimulation, the latter test being made in only one animal. Weigert stains showed the axis cylinders to be well myelinated.

IV. ANASTOMOSIS OF THE DISTAL END OF THE DIVIDED RECURRENT LARYNGEAL INTO A LONGITUDINAL SLIT IN THE OPPOSITE RECURRENT LARYNGEAL NERVE

EXPERIMENT 9.—In Animal 9, the severed right recurrent was placed in a slit in the left intact nerve, Nov. 11, 1924. Neither cord moved at the com-

pletion of the operation. Observation seven weeks later showed movement of both cords; the right cord was observed to move almost as freely as the left. The dog was anesthetized several days later in order to cut the superior laryngeal nerve, but the animal died from the anesthetic; hence, no observation on the effect of stimulation could be made.

The anastomosis was found to be intact at necropsy. The vocal cords appeared normal. The nerves removed for microscopic study were lost during the process of embedding.

EXPERIMENT 10.—In Animal 16, the left recurrent was severed and anastomosed into the side of the opposite recurrent, Jan. 24, 1925. Neither cord moved at the completion of the operation. The animal died of pneumonia

Fig. 8 (Experiment 11).—Longitudinal section distal to anastomosis of recurrent laryngeal and descending hypoglossal nerves at eleven weeks, demonstrating axis cylinders (× 500); Cajal method.

twenty-five days after the anastomosis. Weigert stains of the left recurrent nerve distal to the anastomosis showed a few definite rings of myelin which seemed to be mainly in the periphery of the nerve (Fig. 7).

Results are not conclusive because of the death of one animal during anesthesia seven weeks after the operation and of the other of pneumonia after twenty-five days. Definite movement of the paralyzed cord was observed after seven weeks in one animal but was not noted in the other. A Weigert stain of the nerve distal to the anastomosis in the latter animal showed definite rings of myelin after twenty-five days.

V. ANASTOMOSIS OF THE DISTAL END OF THE SEVERED RECURRENT NERVE TO THE CENTRAL END OF THE DESCENDING HYPOGLOSSAL NERVE

EXPERIMENT 11.—In Animal 8, the anastomosis was made on the left side, Nov. 4, 1924. Slight movement of the left cord was observed eight weeks later. Jan. 27, 1925, almost twelve weeks after the operation, the left cord was seen to move very definitely: division of the left superior laryngeal nerve did not affect the movement of the left cord. The response following direct stimulation of the recurrent nerve distal to the anastomosis was very marked, but no

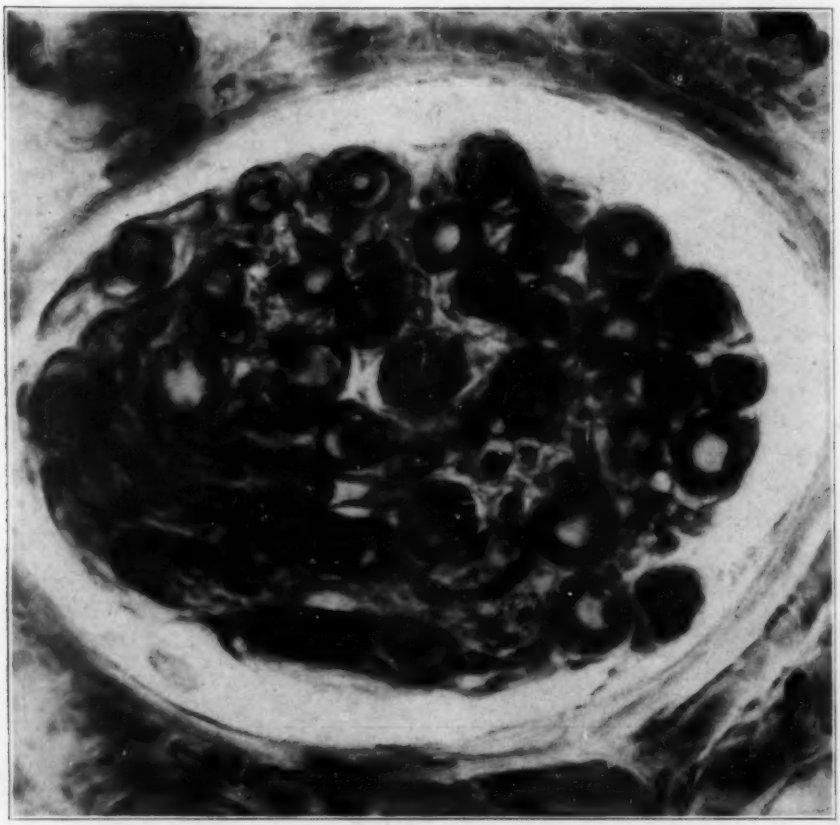

Fig. 9 (Experiment 11).—Cross section distal to anastomosis of recurrent laryngeal and descending hypoglossal nerves at eleven weeks, demonstrating myelin sheaths (× 1,200); Weigert stain.

response was obtained when the point stimulated was central to the anastomosis. This point will be discussed later. The vocal cords were not atrophic. The animal was sacrificed.

The distal portion of the recurrent nerve was studied by the Cajal and Weigert methods. The former stain showed well formed axis cylinders (Fig. 8). The latter showed complete myelinization in a portion of the nerve and smaller myelin rings in the remainder (Fig. 9).

EXPERIMENT 12.—In Animal 10, the anastomosis was made on the left side, Nov. 18, 1924. In addition to the anastomosis between the central end of the descending hypoglossal and the peripheral end of the recurrent laryngeal, the distal end of the descending hypoglossal nerve and the central end of the recurrent laryngeal nerve were united, in an attempt to restore the nerve supply to the infrahyoid muscles. Definite movement of the left vocal cord was observed twelve weeks after the operation. A powerful movement of the left vocal cord followed direct stimulation central to the anastomosis, and the muscles supplied by the descending hypoglossal contracted when the recurrent nerve central to the recurrent hypoglossal anastomosis was stimulated.

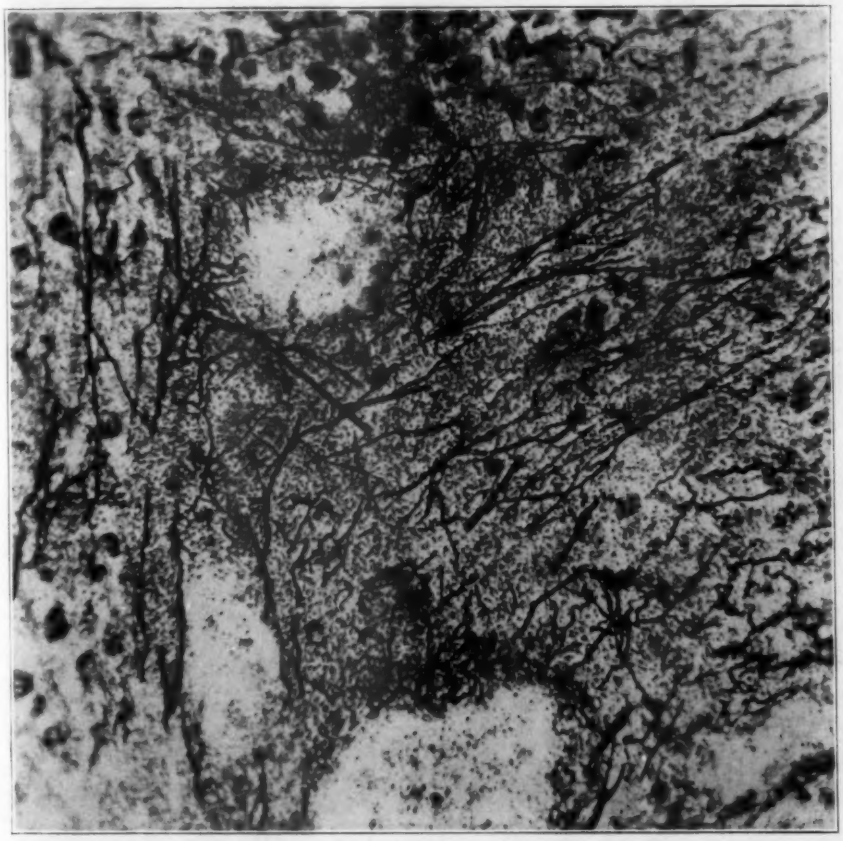

Fig. 10 (Experiment 12).—Longitudinal section distal to recurrent laryngeal and descending hypoglossal anastomosis, demonstrating axis cylinders (× 500) at twelve weeks; Cajal stain.

Both nerves distal to the anastomosis showed regenerated axis cylinders (Figs. 10 and 11). A Weigert stain of the recurrent nerve just before it entered the larynx showed a few well formed myelin sheaths and many small rings of myelin (Fig. 12).

EXPERIMENT 13.—In Animal 13, the right recurrent nerve was divided and anastomosed as near the larynx as possible, Dec. 13, 1924. Paralysis of the

right vocal cord was noted at the completion of the operation. Observation one week later showed no movement on the right side. The cords were observed again, December 30, and the right cord was then seen to have a very definite involuntary movement. The animal was killed four days later; unfortunately, no attempt was made to stimulate the nerve electrically.

At necropsy the point of anastomosis was found intact and unusually free from scar tissue. No tissue was saved for a Weigert stain, but serial sections of the point of anastomosis with about 1 cm. of the nerve on each side showed a regeneration of axis cylinders.

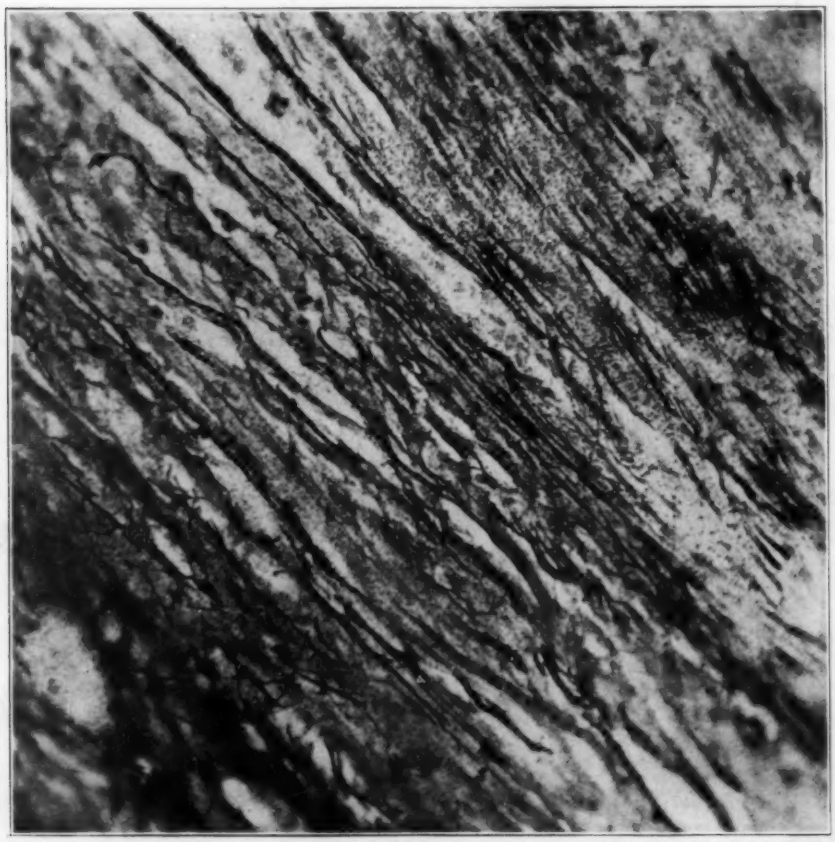

Fig. 11 (Experiment 12).—Longitudinal section of the descending hypoglossal nerve distal to an anastomosis to the recurrent laryngeal nerve at twelve weeks, demonstrating axis cylinders (× 500); Cajal stain.

EXPERIMENT 14.—In Animal 14, the left recurrent nerve was anastomosed to the descending hypoglossal and 1 inch (2.5 cm.) of the superior laryngeal nerve was resected at the same time. The left cord was motionless at the completion of the operation. It was thought that the cord moved slightly four weeks later, but no movement resulted when the nerve was exposed and stimulated. The animal died during an ether anesthesia eleven weeks after the operation,

and just before the second stimulation test was made. Definite involuntary movement of the cord was observed at this time.

The vocal cords appeared normal in microscopic section. A Weigert stain of the distal recurrent nerve showed definite rings of myelin (Fig. 13).

Four experiments presenting histologic and physiologic evidence of regeneration were performed in this group. It was difficult to understand the movement in Experiment 13, and we laid no emphasis on this one experiment. However, as the anastomosis was intact and as no other nerve connection with the larynx (except the superior laryngeal) could be found on that side, it was impossible to ignore the early return of function in this animal.

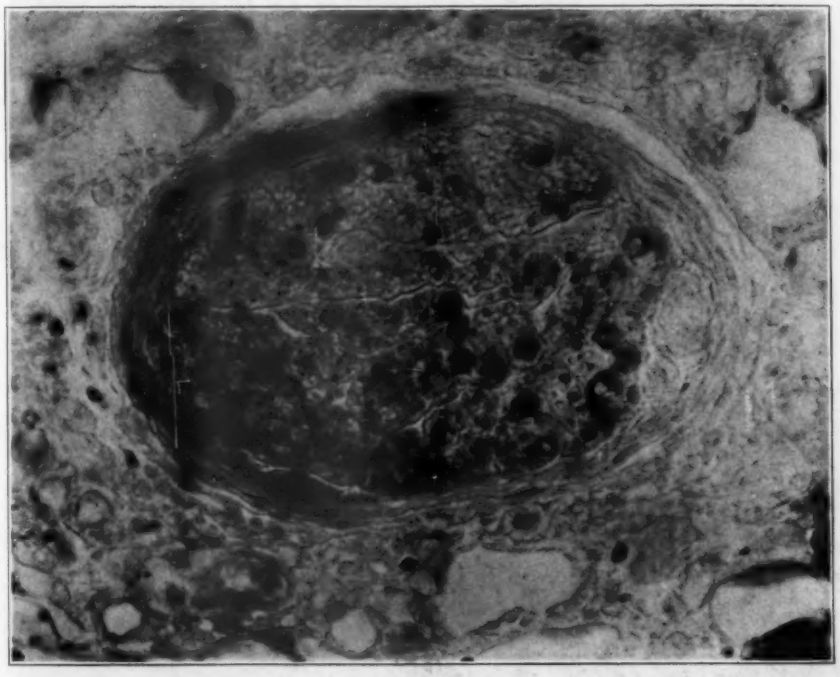

Fig. 12 (Experiment 12).—Cross section distal to recurrent laryngeal and descending hypoglossal nerve anastomosis at twelve weeks, demonstrating myelin sheaths (× 1,200); Weigert stain.

COMMENT

A study of the protocols and illustrations gives evidence of regeneration following the anastomosis of the distal end of the recurrent laryngeal to (1) the upper root of the phrenic (end to end); (2) the trunk of the phrenic (end to side); (3) the trunk of the vagus (end to side); (4) the descending hypoglossal (end to end), and (5) the opposite recurrent laryngeal nerve (end to side). The data we present includes direct

observations on the movements of the cords both with and without stimulation, and histologic studies on the nerve trunks distal to the anastomosis.

EVIDENCES OF REGENERATION

1. *Return of Movement.*—The observations were usually made when the animals were under light anesthesia. Ballance [4] states that in his experimental work on the anastomosis of the recurrent laryngeal nerve

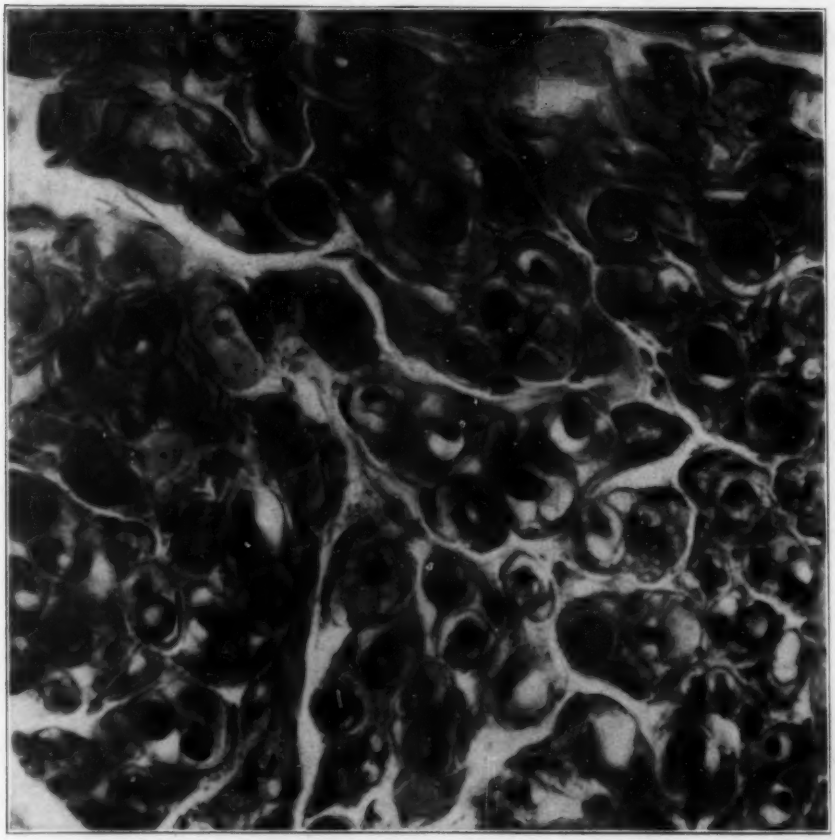

Fig. 13 (Experiment 14).—Cross section distal to recurrent laryngeal and descending hypoglossal nerve anastomosis at eleven weeks, demonstrating myelin sheaths (×1,200); Weigert stain.

to the descending hypoglossal nerve and the vagus no movement of the cord was observed during tranquil respiration. He noted, however, that very evident movement occurred when the animals were partially asphyxiated. We do not think that the light anesthesia used in our cases

4. Ballance, Charles: Brit. M. J. **2**:349 (Aug. 30) 1924.

corresponds to partial asphyxiation but certainly it causes deeper and more rapid respiratory movements, and hence the excursion of the vocal cords is more marked. The movement under these conditions was never as free as that on the sound side.

In many of the animals the superior laryngeal nerve was severed in order to rule out any effect that this nerve might have on the movement of the cord. No evident effect was observed in any of these animals.

When the recurrent nerve was anastomosed to the descending hypoglossal, movement of the cord usually returned earlier than it did in the other experiments and the excursion was thought to be greater. These findings are probably explained by the fact that the anastomosis was made as close as possible to the larynx in these animals and the axis cylinders had a shorter distance to traverse before reaching the end organs in the intrinsic laryngeal muscles.

2. *Reaction to Stimulation.*—An observation made on the movement of the vocal cords when the nerve is exposed and stimulated electrically is much less subject to error than are the observations on the involuntary movements of the cords under ether anesthesia. The nerve was exposed and stimulated in at least one case in each type of anastomosis with the exception of the group in which the opposite recurrent nerve was used. The nerve responded to electrical stimulation by causing an abduction of the vocal cord. We did not continue this long enough to get an adductor response which is thought to result when the abductors become fatigued.

In Experiment 8, movement resulted from stimulation slightly distal to the anastomosis but there was no response a few minutes later when the point stimulated was proximal to the anastomosis. The failure to react when the stimulated point was proximal to the anastomosis may possibly have been due to the inability of a weak current to pass through the anastomosis, whereas, the normal impulse did pass. We regret to say that the amount of stimulus applied was not measured.

3. *Histologic Studies.*—The site of the anastomosis with about 1 cm. of the nerve trunk on each side was taken in most instances to be treated by either the Bielchowsky or Cajal methods for staining axis cylinders. This method of study was quite difficult because of the uncertainty of silver stains and on account of our failure in some instances to get a longitudinal section through the anastomosed nerves, which were less than 1 mm. in diameter. None of the animals were killed in a shorter interval than three weeks after the original operation, which assured us that the axis cylinders in the photomicrographs (distal to the anastomosis) were newly formed ones. We made no attempt to find out how soon the axis cylinders will grow through the anastomosis. Such experi-

ments have been reported in great detail by Kirk and Lewis,[5] who worked with peripheral nerves. Individual variations in the ability of various nerves to regenerate was suggested by the early return of movement in Experiment 13, in which the paralyzed cord began to move in three weeks, and by the newly formed myelin rings in Experiment 16 twenty-six days following the operation (Fig. 7). Huber[6] reports an experimental case of a cable transplant in which the nerve axes had penetrated all the funiculi of four transplanted nerve segments to the extent of 2 cm. in twenty-six days.

Our best histologic proof of regeneration was derived from the Weigert stains. A piece of the nerve near the larynx, but distal to the anastomosis, was removed in most of the experiments at the time of necropsy. Sections of these nerves showed various degrees of remyelinization. The amount of myelin seemed fairly proportional to the length of time after the original operation and to the distance of the anastomosis from the larynx. The myelinization was more complete in the cases in which the end of the recurrent nerve was placed into a slit in the vagus, but was not as perfect in any case as that seen in a normal recurrent nerve (Fig. 14). The growth of axis cylinders preceded the myelinization; hence, the photomicrographs of the nerves stained by the Weigert method imply that axis cylinders occupied all the rings of myelin. The latter stained intensely black.

Many observers, including Kirk and Lewis,[5] have emphasized the important part played by the neurilemmal nuclei in the process of regeneration. Every section that was stained with hematoxylin and eosin showed a marked hyperplasia of these nuclei at the site of the anastomosis. A similar stain was used to demonstrate the continuity of the nerve through the anastomotic site.

TOPOGRAPHY OF NERVES

The importance of bringing directly together similar parts of the two nerves to be anastomosed is advocated by many investigators. It is undoubtedly true that regeneration occurs more quickly if one cut surface is in fairly close relation to the other than it does when a great distance or a mass of fibrous tissue separates them. However, we doubt the value of an attempt at such accurate approximation. The nerves dealt with in these experiments were minute, and at times it was quite impossible to be certain that the severed end of one approximated the severed end of the other. Yet, we see that rapid regeneration occurred not only when the ends of the two nerves were connected loosely with a silk thread but also when the distal end of the recurrent was placed into a slit in an adjacent sound nerve.

5. Kirk and Lewis: Bull. Johns Hopkins Hosp. **28**:71 (Feb.) 1917.
6. Huber, G. C.: Surg., Gynec. & Obst. **30**:464 (May) 1920.

CHOICE OF NERVE

Return of movement of the paralyzed cord was noticed slightly earlier when the descending hypoglossal nerve was used. This was probably owing to the fact that the anastomosis was made closer to the larynx and the regenerating nerve had a shorter distance to grow. As was reported by Ballance [4] and confirmed by one of our experiments (Experiment 12), the muscles innervated by the descending hypoglossal regain

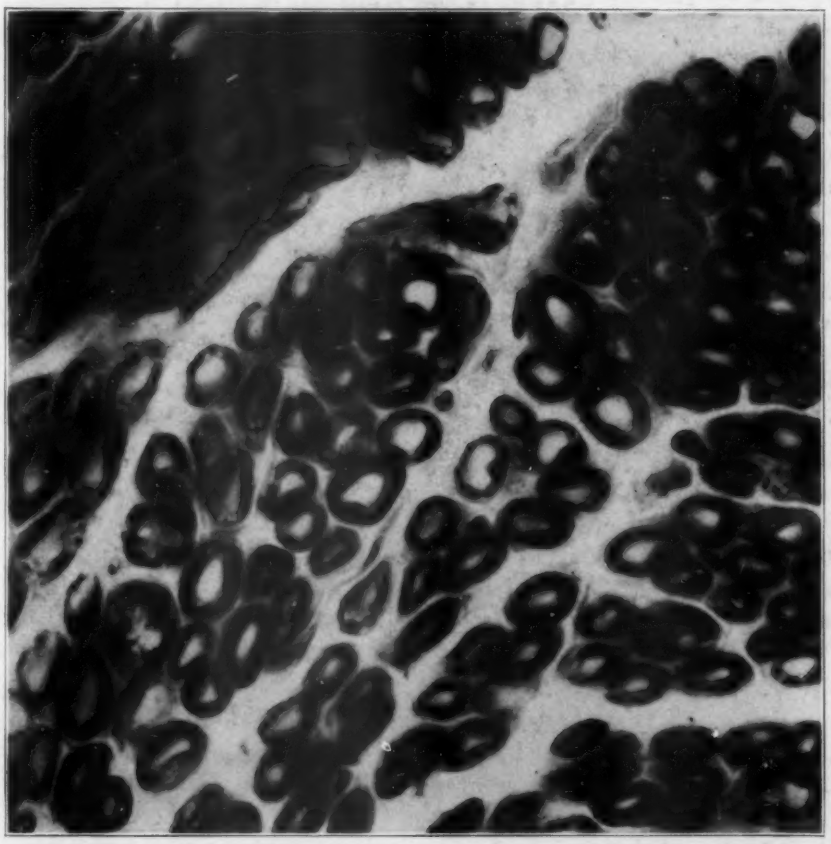

Fig. 14.—Cross section of normal recurrent laryngeal nerve, demonstrating myelin sheaths (× 1,200); Weigert stain.

their function when the central end of the recurrent laryngeal is anastomosed to the distal end of the descending hypoglossal nerve. The chief advantages of the descending hypoglossal nerve are its immediate proximity to the larynx and the fact that it is not a vital nerve.

The entire severance of the phrenic or the vagus for the purpose of anastomosis involves a needless risk. Ballance [4] has reported an experiment in which he secured a too powerful contraction of the vocal cord

following anastomosis with the phrenic nerve. The phrenic nerve would seem to be the ideal nerve to use because of the close association between the movements of the diaphragm and the larynx. Ballance states that permanent paralysis of the diaphragm may be avoided by anastomosing a motor nerve to the distal severed end of the phrenic nerve. It seems to us, however, that the use of the entire phrenic nerve is a rather dangerous procedure and should not be attempted until other means have failed. The point also arises as to whether or not a patient would have control over the voice after such an anastomosis, as the vocal cord would be expected to move whenever an impulse was sent to the diaphragm. The same question is raised regarding the type of anastomosis performed in our experiments (end of recurrent nerve to slit in phrenic nerve). However, we did not encounter any violent contractions such as Ballance found when using the entire phrenic nerve. The movements of the diaphragm were not studied carefully following use of the phrenic nerve, but no abnormality was made out at necropsy. We have recorded some good results when the vagus was used in an end to side anastomosis. We do not know of any ill results following the use of this nerve, but in a clinical case it would be better to use the descending hypoglossal nerve.

The use of the upper root of the phrenic nerve had not been tried previously so far as we are aware. Histologic studies of the trunk of the phrenic nerve and of the diaphragm showed no abnormalities following the use of this branch. The only objections to its use are its rather small size and its position in the neck. When the recurrent laryngeal nerve is injured during a surgical procedure, it is usually at a point very near the larynx. The upper root of the phrenic nerve is too short, and if the injury is close to the larynx the anastomosis is difficult to perform without placing the nerves under tension. Except for the two reasons mentioned, this type of anastomosis seems the most ideal, because it does not result in a paralysis of any part and because the functions of the larynx and the diaphragm seem more closely related than those of the larynx and the neck muscles that are supplied by the descending hypoglossal. The length of time between the operation and the return of movement was longer in this group than when the descending hypoglossal was used, but this is explained by the greater distance over which the nerve had to grow.

Because of the great vulnerability of the recurrent laryngeal nerve, an end to side anastomosis of the severed to the sound nerve is not expedient. Following this procedure, even when the greatest care is exercised, a paralysis on both sides was noted immediately after the operation. Such a condition renders the subject more liable to pulmo-

nary infections, and returning function might be associated with marked inspiratory stridor due to the contraction of the adductor muscles.

The descending hypoglossal is probably the nerve of choice in the majority of cases owing to the proximity of this nerve to the larynx. Frazier [7] has reported improvement following its use in patients. However, if it is possible to use the upper root of the phrenic nerve, we think that a more nearly perfect functional result may be obtained. We have noted good results following both these types of anastomosis and we think that either of them is to be preferred to an end to side anastomosis of the severed recurrent nerve to the vagus or the phrenic nerve. Since this work was finished, Cooledge,[8] working with Ballance, reports a case in which movement returned after an anastomosis of the recurrent laryngeal nerve into a slit in the phrenic nerve. He states, "The entire trunk of the phrenic is not necessary and probably it will be found sufficient to use half the trunk, as in a lateral anastomosis, or one of the roots arising from the cervical nerves."

VOCAL CORDS

Our studies on the vocal cords are not conclusive. In several instances the vocal cord on the side of the operation looked somewhat atrophic when observed during the life of the animal, but on gross examination at necropsy in every experiment the vocal cords were identical on the two sides. Longitudinal sections were made of the cords in every case and stained with hematoxylin and eosin. Owing to the fact that the cords vary so much in their structure at different levels and because of our inability to cut the two cords at exactly the same level, we are unable to make a just comparison. It is our feeling that there is no definite atrophy in any case. This is probably owing to the fact that the true cords are composed largely of elastic tissue and nutritive changes take place slowly. MacKenzie [9] states, "Atrophy of the vocal cords is extremely rare and, as far as I am aware, has not been proved to exist by postmortem evidence."

SUMMARY

In observations and histologic studies on seventeen experimental animals in which various nerves were anastomosed to severed recurrent laryngeal nerves, the nerves that were employed were: (1) the descending hypoglossal (end to end); (2) the main trunk of the vagus (end to side); (3) the main trunk of the phrenic (end to side); (4) the root

7. Frazier, C. H.: Ann. Surg. **79**:161 (Feb.) 1924.

8. Cooledge, Lionel: Brit. M. J., No. 3351, p. 547 (March 21) 1925.

9. MacKenzie, Morrill: Diseases of the Pharynx, Larynx and Trachea, New York, William Wood & Co., 1880, p. 347.

of the phrenic which comes from the third cervical nerve (end to end), and (5) the opposite recurrent laryngeal nerve (end to side). The observations on the movements of the cords after anastomosis were made while the animals were under light ether anesthesia. In most of the cases, the response to direct electrical stimulation of the nerve proximal and distal to the anastomosis also was noted. The histologic studies consisted in the main of preparations which were stained by Bielchowsky, Cajal and Weigert methods.

There was definite evidence of regeneration following the use of each of the nerves listed above. We have emphasized the point that conclusions drawn from observations on the movement of the cord during anesthesia are not reliable; electrical stimulation of the recurrent on either side of the anastomosis, histologic demonstration of new axis cylinders, regeneration of myelin sheaths and the increased number of neurilemmal nuclei are necessary to prove a return of function in an animal. The descending hypoglossal and the upper root of the phrenic seem to be the nerves of choice. The advantages of the descending hypoglossal are that it is situated near the larynx (operative injuries to the recurrent laryngeal usually occur near the larynx) and that it is a larger nerve than the upper root of the phrenic. The latter nerve has in its favor the fact that it is a respiratory nerve, and hence is better suited to supply impulses for the delicate movements of the vocal cords. Further, the use of the upper root of the phrenic nerve in the dog does not result in a paralysis of any part of the diaphragm.

CALCANEAL SPURS

PHILIP LEWIN, M.D.
Assistant Professor of Orthopedic Surgery, Northwestern University Medical School; Attending Orthopedic Surgeon, Cook County Hospital; Junior Attending Orthopedic Surgeon, St. Luke's Hospital
CHICAGO

The subject of calcaneal spurs is very important and has not received its proper consideration. The object of this article is to review the literature and report two unusual cases. The literature on this subject is not extensive. A few excellent articles have been written, especially by Baer and Swett.

ETIOLOGY

It is the customary teaching that all calcaneal spurs are gonorrheal in origin. This is grossly wrong. The various factors are as follows: First, focal infections with the ordinary cocci, gonococci and spirochetes; second, metabolic disturbances, especially of gastro-intestinal and gall-bladder origin (I have seen a large number of cases in which the metabolic factor either was most important or was an element in the exaggeration of other factors, possibly in the nature of a sensitization process); third, trauma, due to injury and improper shoes; fourth, static, due to flatfeet, and fifth, a pathologic condition of the plantar fascia—a short plantar fascia pulling on its attachment to the os calcis.

PATHOLOGY

Normal Anatomy.—The normal anatomy of this region is very simple. There is the plantar fascia which takes its origin from the tuberosity of the os calcis. If pressure is applied to this area or if the plantar fascia pulls on its attachment, there will result a slight separation or pulling off of the periosteum at this point. Owing to the stimulation of trauma or infection or both, osteogenesis occurs more actively and a vicious cycle is established, i. e., as the periosteum separates new bone formation occurs and a spur results. There is proliferation of the osteogenetic layer of the periosteum resulting in spur formation.

Symptoms.—The symptoms are pain, tenderness, swelling and limp. The onset is usually gradual except when due to an infection, such as acute arthritis, when it may be very acute. The pain and tenderness are usually in the internal lateral border of the os calcis or at the attachment of the plantar fascia. The roentgenogram may or may not reveal a bony spur, depending on the duration of the pathologic condition and the density of the spur. Many very painful heels are seen, roentgenograms of which reveal no spurs.

Fig. 1 (Case 1).—Osteoma of os calcis before operation.

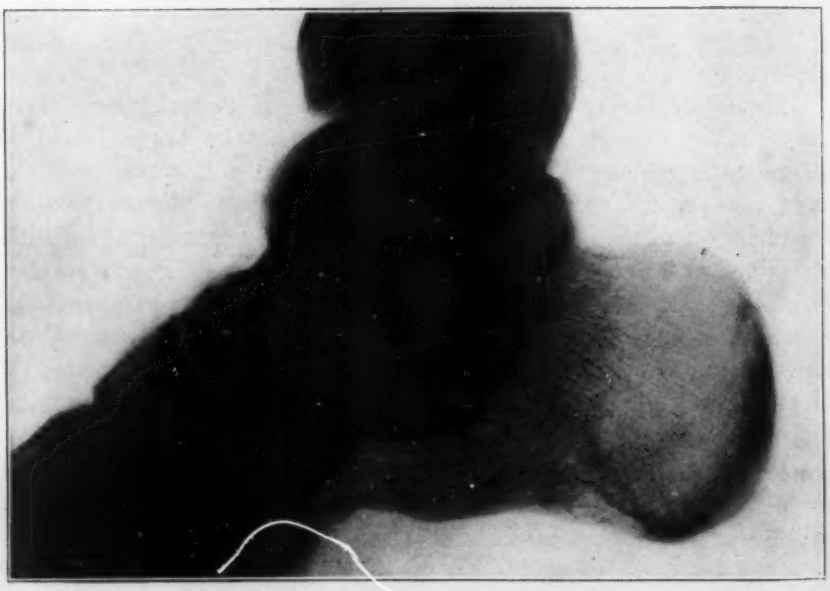

Fig. 2 (Case 1).—Appearance of heel after operation.

Diagnosis.—The diagnosis is usually easy. The differential diagnosis rests between osteoma, flatfoot and arthritis.

Prognosis.—The prognosis of complete relief is good if the spur is the only cause of trouble. If there is an arthritis of the foot, removal of the spur will not give sufficient relief. Most patients can be made comfortable without operation, others are not cured by operation. There may be recurrence of symptoms and spur formation, in the same or the opposite foot.

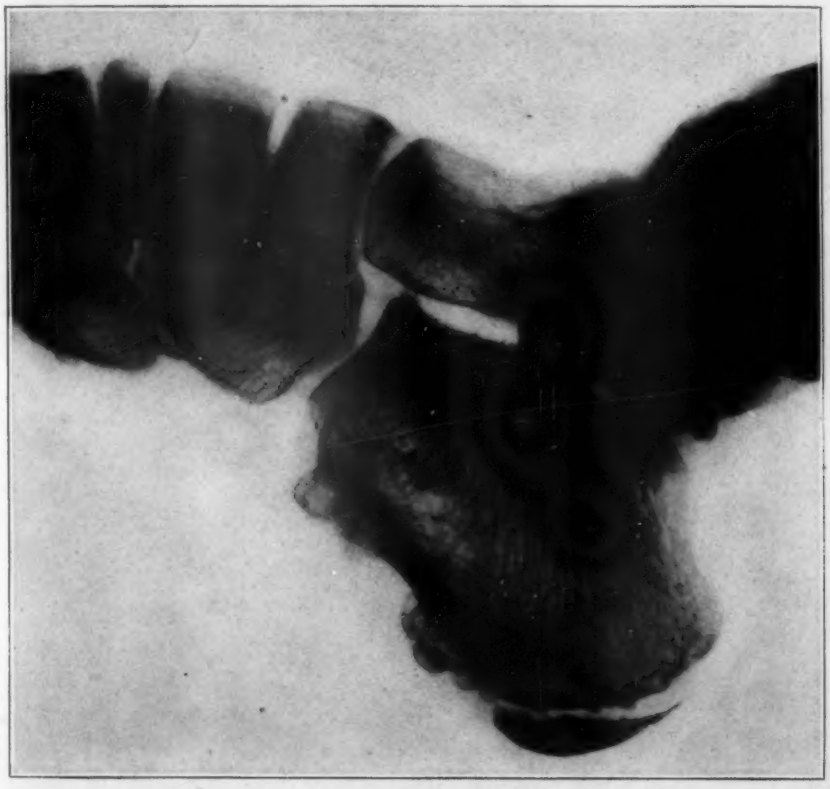

Fig. 3 (Case 2).—Multiple cartilaginous exostoses of os calcis.

NONOPERATIVE TREATMENT

The etiologic factors, the residue of a gonococcus infection, infected tonsils or teeth, should be treated if they can be found. The gastrointestinal condition should be relieved if possible. Weight bearing should be discontinued, and bed treatment, consisting of the application of an anodyne lotion plus fomentations, should be given. An excellent anodyne lotion in extensive use at St. Luke's Hospital and known as Porter's lotion is as follows: Tincture of opium, 30 c.c.; diluted solu-

tion of lead subacetate, 40 c.c.; tincture of arnica, 50 c.c.; extract of hamamelis, 60 c.c. The bottle should be shaken.

Directions for the use of this lotion are as follows: The entire foot and ankle are covered by four layers of gauze saturated with the lotion and enclosed in oiled silk or rubber sheeting. Hot fomentations of strips or pads of flannel are wrung out of hot water, about six layers wrapped around the impervious layer and another sheet of oiled silk applied. A hot water bag is placed at the side or under the foot and

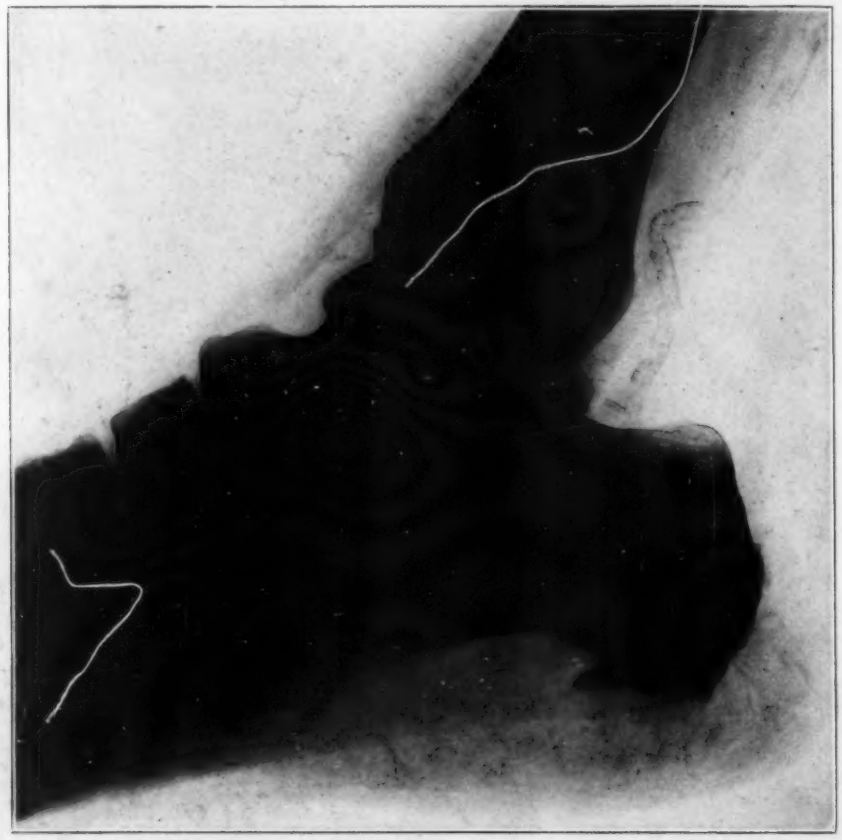

Fig. 4.—Common type of calcaneal spur with arteriosclerosis.

everything enclosed in a Turkish towel. The foot should be elevated. A small amount of lotion is added and the fomentations renewed three times daily.

After all pain and most of the sensitiveness have disappeared, plaster-of-Paris casts should be applied. Proper shoes are prescribed after from two to four weeks of wearing casts. Shoes should be high, laced, of straight last, round toe, rigid shank at first, and medium width

shank. Felt pads are inserted in the shoes to relieve weight bearing on painful areas. The heel of the shoe should be entirely removed and a low rubber heel substituted.

Tilanus relieved some of his patients of pain by roentgenotherapy.

The janitor at Northwestern University Medical School hit on an unusual method of treating his own painful heels; he pounded his heels with the flat side of a hammer daily for many months and experienced marked relief.

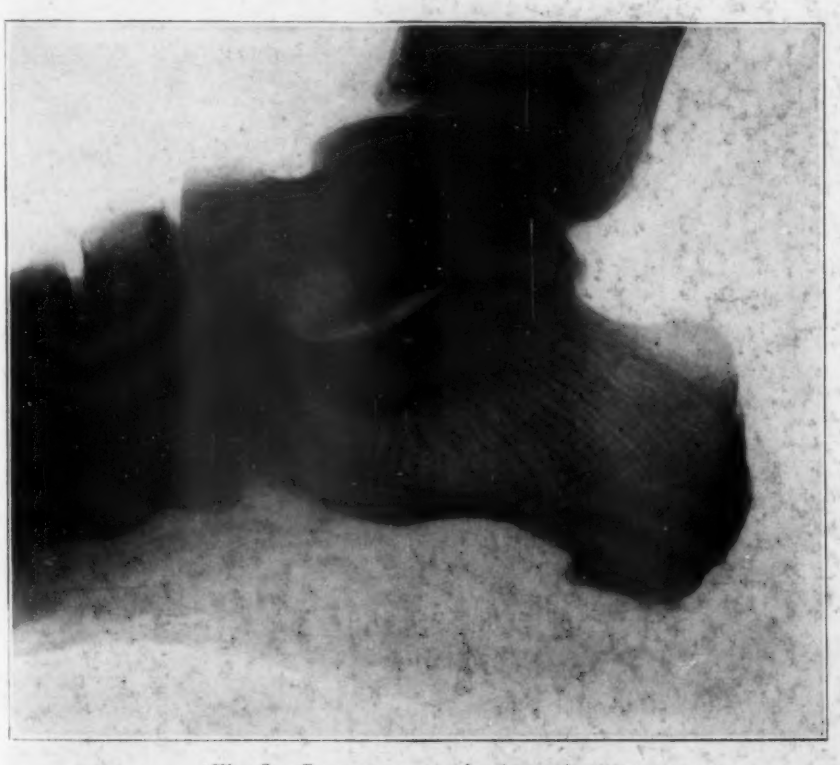

Fig. 5.—Common type of calcaneal spur.

OPERATIVE TREATMENT

Operative treatment consists in the removal of the spur. Operative trauma often stimulates osteogenesis, especially if the infectious agent is still operating. The size of the spur is not the determining factor. The incision should be made along the inner border of the heel. The removal of the spur is accomplished by means of a chisel and mallet. Plaster casts are applied and should remain for about ten days.

POSTOPERATIVE CARE

Postoperative care consists in the relief from weight bearing by means of proper shoes into which are inserted weight relieving felt

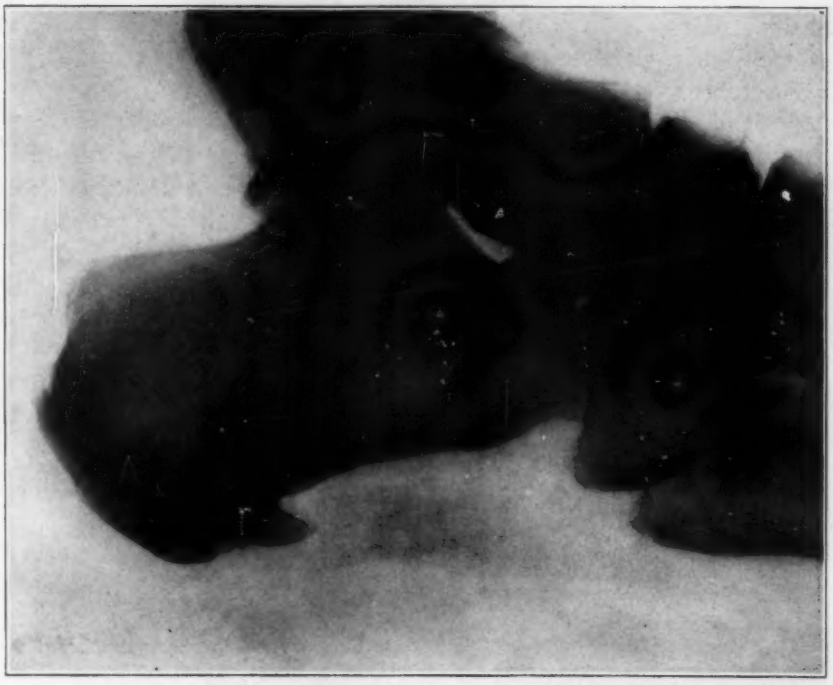

Fig. 6.—Well developed, calcified calcaneal spur causing no symptoms.

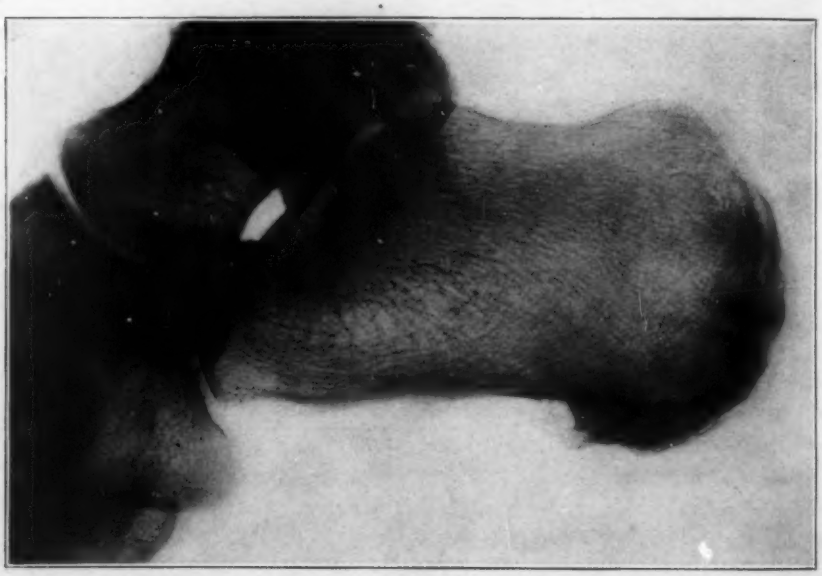

Fig. 7.—Very slight spur formation of os calcis causing intense pain and sensitiveness in the heel.

pads. The diet should be considered very important in cases of metabolic disturbance, and these cases are very common. As a rule, meat, eggs and fish are contraindicated. Diathermy is beneficial for an accompanying arthritis.

REPORT OF CASES

CASE 1.—A white boy, aged 9 years, entered Cook County Hospital complaining of pain in the right heel. Examination revealed tenderness over the attachment of the plantar fascia to the os calcis and a definite bony mass easily palpable. A roentgenogram revealed a definite bony tumor (Fig. 1). This mass was removed by chisel and mallet (Fig. 2). A plaster cast was applied and removed at the end of three weeks. The patient made a perfect recovery and was entirely relieved of his pain, tenderness and limp.

The diagnosis was osteoma of the os calcis.

CASE 2.—A white boy, aged 13 years, was referred to me by Dr. G. E. Van Demark of Sioux Falls, S. D., with a marked case of multiple cartilaginous exostoses. There were probably fifty excrescenses of the pelvic and long bones (Fig. 3). No operation was permitted.

COMMENT

It is highly inadvisable to remove calcaneal spurs unless they are the cause of the patient's complaint, or unless one feels that removing the spur will give the patient a comfortable foot. The situation is analogous to operating on hallux valgus; after a perfect operation, the patient may still have painful feet due to conditions outside the big toe area, such as metatarsalgia.

7 West Madison Street.

THE TRANSFUSING OF UNMODIFIED BLOOD

II. THE TECHNIC IN ONE THOUSAND CASES *

OSBORNE A. BRINES

DETROIT

Since the appearance of the first paper [1] from this clinic on the subject of blood transfusing, numerous inquiries have been received regarding the details of the method described. I thought best, however, to await the completion of at least the first 1,000 transfusions before answering these questions and then to answer them in the form of an article. It was hoped thus to encourage and promote a more extensive use of blood transfusions by emphasizing and recommending a method that is simple and consistently successful. The time has now arrived when it is possible to set down results of our experience with one method in 1,000 transfusions.

The theory advanced a few years ago that the transfusing of unmodified blood is the most beneficial to the patient has now become a well established fact. Any attempt to retard coagulation by the addition of drugs impairs the value of the blood from a biologic and immunologic point of view, to say nothing of the bacterial contamination usually accompanying the process of preventing coagulation. Lewisohn,[2] the originator of the citrate method, strongly recommends this procedure and minimizes the findings of others that there are certain objections to its use. He finds that in his hands transfusions by the citrate method are followed by a no higher percentage of reactions than the method of Unger. However, nearly all the published reports on blood transfusion work found in the literature of the last few years disagree with the experience of Lewisohn in favor of the belief that whole blood transfusions are the most valuable. And after all we are more concerned with the results and experiences of the majority of workers scattered throughout the world than we are with those of one man or just a few men. Lewisohn and also Mellon, Hastings, and Casey [3] criticize the statements of Unger [4] and attempt to disprove his results.

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* From the Jefferson Clinic and Diagnostic Hospital.

1. Brines, O. A.: Transfusing of Unmodified Blood, Arch. Surg. **7**:306-320 (Sept.) 1923.

2. Lewisohn, R.: Chills Following Transfusion of Blood, J. A. M. A. **80**: 247-249 (Jan. 27) 1923; Citrate Method of Blood Transfusion, Boston M. & S. J. **190**:733 (May 1) 1924.

3. Mellon, R. R.; Hastings, W. S., and Casey, G. U.: Effect of Sodium Citrate on the Blood, J. A. M. A. **79**:1678-1681 (Nov. 11) 1922.

4. Unger, L. J.: Deleterious Effect of Sodium Citrate Employed in Blood Transfusion, J. A. M. A. **77**:2107 (Dec. 31) 1921.

Unger's views, nevertheless, are supported by others. Colebrook and Storer,[5] basing their conclusions on carefully executed experiments, believe that the destruction of streptococci and staphylococci depends on the phagocytic action of the leukocytes plus the opsonic power of the plasma, and that the decalcifying agents added to normal blood reduce the power of the blood to kill streptococci and staphylococci due to interference with the action of the leukocytes. Agnew[6] also thinks that sodium citrate reduces the opsonic index and phagocytic power of the blood and destroys complement and the blood platelets. There are many who are convinced that sodium citrate increases the incidence of posttransfusion reactions. Among these is Lederer,[7] who reports forty-seven transfusions by the citrate method with 49.5 per cent. reactions and another series of forty-nine transfusions with whole blood in which there were no reactions. Kretzler[8] regards a direct method superior to citration as far as reactions are concerned. Bacon[9] advocates that the citrate method which carries with it heavy liabilities should be discarded as far as possible.

Joannides and Cameron[10] have come to the defense of the citrate method and although they report no experience with patients, they have conducted experiments on dogs to prove their contentions. These workers incorrectly quoted me as saying in a previous article[1] that a citrate transfusion was a most dangerous procedure in exsanguination, and that exsanguination increases the susceptibility of the patient to the toxic effects of sodium citrate. They concluded that such a notion was not true at all, but the results of their experiments were not very important because it is doubtful if any one believes that citrated blood would ordinarily produce death. In fact, I am inclined to suppose that if there is any place that citrated blood approaches the value of unmodified blood it is in exsanguination. The editorial writer of *The Journal of the*

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5. Colebrook, L., and Storer, E. J.: Immunotransfusion, Lancet **2**:1341-1344 (Dec. 22) 1923; cont., **2**:1394-1398 (Dec. 29) 1923.

6. Agnew, G. H.: Blood Transfusion; Factors Frequently Overlooked, Canad. M. A. J. **14**:5388 (May) 1924.

7. Lederer, M.: Citrate Versus Unmodified Blood Transfusion, Surg., Gynec. & Obst. **37**:221-224 (Aug.) 1924.

8. Kretzler, H. H.: Posttransfusion Reactions; Comparison of Citrate and Syringe Methods, Northwest. Med. **23**:358 (Aug.) 1924.

9. Bacon, D. K.: Choice of Method in Blood Transfusion, J. A. M. A. **82**:1187-1189 (April 12) 1924.

10. Joannides, M., and Cameron, L.: Citrated Blood Transfusion. J. A. M. A. **82**:1187-1189 (April 12) 1924.

American Medical Association[11] correctly summarized my views by saying:

> While the latter (citrate method) should not be abandoned, the whole blood method should, whenever possible, be substituted for it; however, there is never a time when citrated blood is as good as whole blood.

I believe that there are times when the patient is extremely ill that whole blood would save his or her life when citrated blood might fail to do so. My objections to citrated blood were far from being based entirely on the dog experiments of Henderson and Haggard,[12] in which sodium citrate solution was found to be fatal to exsanguinated dogs. The most convincing proof was the reduction in number of transfusion reactions in our cases from nearly 40 per cent., some being quite severe, to the point where they were practically negligible, by changing from the citrate to the whole blood method. Joannides and Cameron used 0.2 per cent. citrated blood in their experiments. This concentration has been found by myself, and also was reported by Pemberton[13] to be insufficient to prevent the coagulation of some human bloods because the coagulative properties of blood of different persons varies and so, in practical work, the concentration has to be raised to 0.25 per cent. and, in rare instances, even higher. For those who wish to perform transfusions by the citrate method, the apparatus illustrated and described by me[1] is strongly recommended as being simplest to operate, providing for the complete citration of the blood as it leaves the vein, the maintenance of strict asepsis, aspiration by vacuum, and injection by pressure. The blood remains in one container throughout the procedure.

Numerous anticoagulants have been used. Sodium citrate has always been by far the most popular, yet ammonium oxalate, sodium phosphate, and even arsphenamin have been successfully used. Norton[14] advocates the use of sodium iodid, and in the department of pharmacology at the Detroit College of Medicine and Surgery[15] it has been found that sodium sulphate is highly efficient, produces the minimum of toxic and deleterious effects, and yet may be administered in large doses.

Five years ago when direct transfusion work was begun at this clinic, the underlying object was to help popularize a method for giving

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11. The Status of Blood Transfusion, Editorial, J. A. M. A. **81**:1114 (Sept. 29) 1923.

12. Henderson, Yandell; and Haggard, H. W.: Hemorrhage as a Form of Asphyxia, J. A. M. A. **78**:697 (March 11) 1922.

13. Pemberton, J. de J.: Blood Transfusion, Surg., Gynec. & Obst. **28**: 262-276 (March) 1919.

14. Norton, W. A.: New Method of Blood Transfusion, Surg., Gynec. & Obst. **39**:92 (July) 1924.

15. MacCraken, W. H.: Personal communication to the author.

whole blood which might become universally used because of its simplicity, its ease of operation, its uniform success, and its freedom from the usual high percentage of failures which in the past had generally attended such procedures. In our opinion the blood should be undiluted, untreated and unmodified. It was obviously necessary that the procedure be divorced from blood vessel surgery, and that nothing more extensive in surgery than simple venous puncture and intravenous injection should be allowable. In other words, we must adhere closely to the use of needles. Provision should be made for the accurate measurement of the blood transferred, and there should be no ball valves or springs in the apparatus to act as collectors of fibrin. It was apparently advisable that the flow of blood should be practically continuous, and that the operation of the apparatus should not be automatic to the extent that the procedure would be robbed of that personal touch that lends success to all medical and surgical technic. It seems reasonable to believe that if all these requirements could be satisfied a perfect method for the transfusion of blood would result.

We believe that any attempt to retard coagulation by physical means, using the methods in vogue, such as a paraffin lined apparatus, introduced elements of uncertainty, involved unnecessary surgical risks, brought about unnecessary blood vessel destruction, and allowed a too great exposure of the blood to the air. It was found that Unger[16] had devised a double stopcock permitting the passage of either blood or saline solution through either the donor's or the recipient's needle. The lack of such a stopcock had been the stumbling block of most previous direct methods, and so this was immediately adopted. The advantage of such a stopcock is that it allows the patient's side of the apparatus to be tested after the needle is presumably in place, allows a continuous flow of saline solution through this needle after it has been placed in position and until the donor's vein can be entered, and permits the assistant to flush the blood out of either side of the apparatus, in case difficulty is encountered and several minutes are necessary for readjustment, during which time the blood would ordinarily clot if allowed to remain in the apparatus. In many transfusions this feature is unnecessary, but it adds materially to success in the more difficult cases; for instance, when several minutes might be consumed in effecting an entrance into the donor's blood vessel. About this nucleus it was possible to perfect a technic that was simple and easily acquired, more especially with the quite recent manufacture of syringes of such quality that they could be filled without leakage of air.

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16. Unger, L. G.: A New Method of Syringe Transfusion, J. A. M. A. **64**: 582 (Feb. 13) 1915; **69**:2159 (Dec. 29) 1917.

The last year has marked several important changes both in our technic and in the Unger type of apparatus that we use. In the first place, the practice of pouring ether on the blood syringe for the purpose of cooling the syringe and thus eliminating the clotting of the thin film of blood that creeps in between the plunger and the barrel, with resulting sticking of the plunger, has been discarded. The reason for this change was primarily for the purpose of dispensing with the services of one assistant; and another reason was that nearly every patient and a large percentage of donors objected to the odor of the ether. It has been found that a transfusion performed without ether is not only more simple than the average one in which ether is used but also equally successful. It is true that a syringe might occasionally "stick" and have to be changed during a transfusion for a fresh one when ether is not used, whereas a single one, ether cooled, might be sufficient. Changing a syringe once or even twice in the course of a transfusion is a small matter. Therefore, the conclusion was reached that ether was a superfluous and an objectionable part of our technic, and its elimination has been justified by the fact that over 400 transfusions have been satisfactorily performed without its use.

Neither is saline solution any longer given along with the blood throughout the transfusion; it is now used only for the purpose of testing the recipient's needle. The reason for attempting transfusions without the use of saline solution during the actual transferring of the blood was based on the belief and observation that the giving of saline solution and blood was injurious to the patient and produced unnecessary reactions. It has been observed that the addition of an inorganic salt to the blood outside the circulation alters it in some way to make it less desirable for intravenous administration. This is a strange phenomenon because the intravenous administration of an isotonic solution of these salts is rarely harmful when given alone, but when added to whole blood in vitro a mixture results which, when injected intravenously, is capable of producing a higher incidence of reaction than pure whole blood.

An explanation of such phenomena cannot readily be given. The various causes of posttransfusion reactions have been discussed in a previous paper from this clinic and little more can be said. It has been believed that normal saline was a necessary feature of the Unger method for the purpose of flushing the blood out of the temporarily unused side of the apparatus before it had time to clot. This is an unsound belief because it requires several minutes for blood to coagulate and the time required for filling and emptying of a blood syringe is usually less than one minute, which provides a large margin of safety against clotting within the apparatus. If more than one minute is

required for the filling and emptying of the blood syringe, the donor's needle has not been properly placed, and in order to insure a successful transfusion another vein in the donor's arm should be selected and a new attempt made. The use of saline solution was abandoned on the ground that it was a useless and an objectionable feature.

The third change is probably the most important. Our apparatuses were formerly provided with attachments for two syringes, one a 20 c.c. Record syringe for the blood, and the other a 50 c.c. metal syringe for the saline solution. In the present model, the adapter for the metal saline solution syringe has been replaced by an attachment for a Record syringe, thus providing the operator and his assistant each with

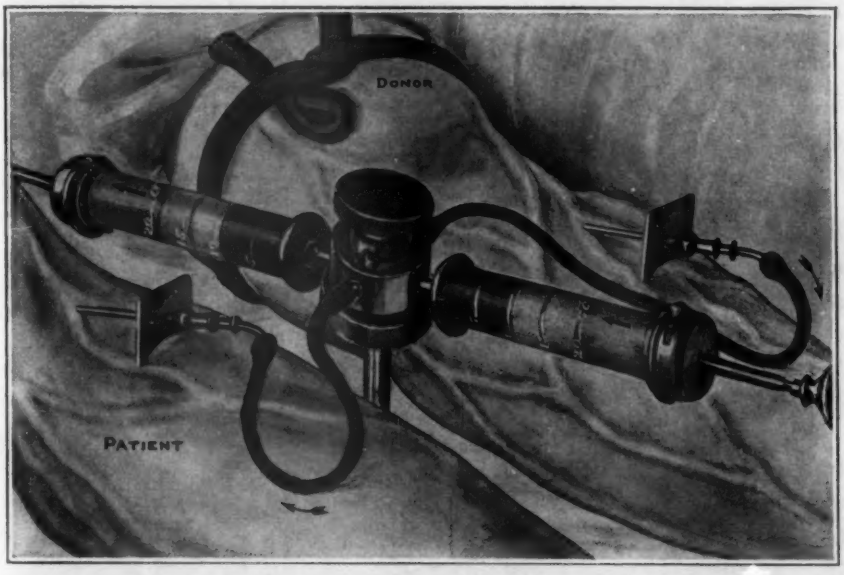

Fig. 1.—Author's modification of the Unger apparatus.

a blood syringe operated at the same time but working in an opposite manner to each other; i. e., when one syringe is being filled the other is being emptied, and vice versa (Fig. 1). This is made possible by the stopcock being so constructed that when the operator's syringe is in communication with the one side of the apparatus, the assistant's syringe is in communication with the opposite side. In other words, when the operator's syringe communicates with the donor's circulation, the assistant is manipulating a syringe that communicates with the recipient's blood stream. When the stopcock is turned to the opposite side, the reverse is true. This arrangement enables the operator to withdraw blood from the donor's vein while the assistant is introducing the donor's blood into the vein of the patient. When the stopcock

valve is reversed, the operator is the one who empties his syringe, and the assistant fills his syringe from the donor's vein. This device has several advantages. In the first place, it provides for a practically continuous stream of blood from the donor to the patient, and the possibility of stagnation of blood and consequent clotting within the apparatus has been essentially removed. Second, it doubles the speed and so halves the time necessary actually to transfer the blood. Speed is no objection in a transfusion provided the patient does not have a weakened myocardium, in which case a reasonable amount of care should be exercised lest a cardiac embarrassment or an acute dilatation be produced. As speed is really the keynote of success in a whole blood transfusion, and stagnation with consequent clotting one of the greatest possible stumbling blocks, the increase in speed and the elimination of stagnation contributes materially to the success of the whole blood method and makes possible the giving of much larger amounts of blood without changing syringes, without cooling the syringes with some rapidly evaporating fluid, and without the addition of saline solution to the blood.

If the services of an assistant are not available, the instrument described may be used as a single action apparatus by inserting a plug, with which all apparatus are now equipped, into the opening for the assistant's syringe during the actual transferring of the blood. The complete apparatus exactly as described here and used at this clinic at the present time, with complete directions for using, can be obtained from the J. F. Hartz Company, Detroit.

Numerous questions have been received regarding the technic of transfusing and the style of apparatus used here. Undoubtedly many operators fail with this method because of the lack of a proper routine or sequence to follow. With this thought in mind, a résumé of our technic will be given. Though somewhat detailed, this will, it is hoped, serve as a text of some value in this work. If carefully followed, it will eliminate most of the difficulties and lead to a greater certainty of success.

The apparatus consists of a four-way stopcock mounted in such a way that it can be attached to a board 1 inch (2.5 cm.) in thickness. Four openings are thus provided. Into one, the nearest to the operator, the blood syringe, a 20 c.c. Record syringe, is inserted. Into the opening on the opposite side of the apparatus, the assistant's syringe is inserted. The other two attachments are in the form of slip-on adapters over which the ends of two pieces of rubber tubing are placed. On the distal ends of the pieces of tubing are attached adapters for Record needles. The inside diameter of the tubing is 2.5 mm., the walls being 1 mm. thick. Tubing with these specifications will not slip off the adapters and

will not collapse. New rubber tubing is used for each transfusion, and this is especially prepared by boiling for one hour in 2 per cent. solution of sodium hydroxid, followed by a thorough rinsing in distilled water.

The type of needles used is highly important. At first we adopted the idea of other workers and tried to use blunt short bevel needles, but it soon became apparent that a sharp needle with a fairly acute angle at the point and fairly long bevel surfaces greatly facilitated the entrance to a vein. It is very important to keep the needle sharp. In our laboratory we have a small motor driven emery wheel which produces a concave bevel surface. Figure 2 illustrates what we believe to be the best type of needle. The apparatus which was assembled under my direction by Hartz was equipped with the proper type of tubing and the needles just described. Needles 1⅓ inches (3.3 cm.) long and in two sizes, 15 and 13 gage, will be found satisfactory in all cases.

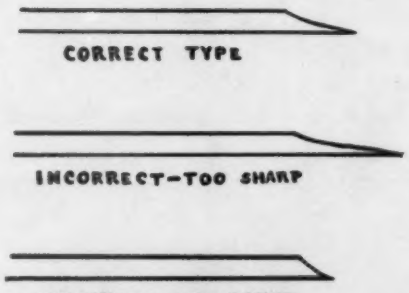

Fig. 2.—Correct and incorrect types of needles.

The sterilization of the apparatus is best carried out immediately after using by carefully and thoroughly wrapping in towels or a sheet and sterilizing in the vacuum autoclave. The outfit is rendered sterile, remains perfectly dry and ready for use and does not rust. Glass parts are sterilized by keeping them in compound solution of cresol between transfusions because of the breakage resulting from sterilization in the autoclave. It is a distinct advantage to have the apparatus always sterile and ready for use. The usual aseptic precautions should be taken in unwrapping and handling the apparatus. Sterile lubricants, such as petrolatum or glycerin, should not be applied to moving parts during the assembling. When the apparatus is assembled and the needles are attached, it should be tested for any obstruction by forcing a syringeful of sterile saline solution through both needles.

The actual technic of the transfusion is quite simple. In this discussion it is to be understood that the term "operator" refers to the person who stands at the side of the apparatus toward the patient's and

donor's feet. The term "assistant" refers to the person who stands at the head of the subject and opposite the operator. Both patient and donor are in a supine position, with their heads pointing in the same direction. The arms are prepared with ether and iodin in the usual manner. Tourniquets are applied to the arms. A Tycos blood pressure apparatus arm band makes the best tourniquet for the donor's arm because the pressure can be altered. The apparatus is set in position and screwed tightly to the board. The assistant's syringe is filled with saline solution and the needles are inserted. It is best to insert both needles "toward the heart." Entrance is first made into the patient's vein because greater difficulty is usually experienced with the patient's blood vessels. Any suitable vessel having the appearance of ready accessibility may be chosen, and it matters very little if the site of the puncture is at the elbow, forearm, wrist, or the back of the hand. In infants one of the superficial temporal veins is often the vessel of choice. In fact, any vein may be employed, but it is preferable in the case of the donor to select a vein that is more or less deep seated and firmly fixed by subcutaneous tissue, rather than some of the large, superficial, sinus-like vessels so commonly found on the ventral surface of the forearm in males, and which collapse so easily when aspiration is attempted.

The recipient's needle once in position, the tourniquet is removed and saline solution is allowed to flow slowly from the assistant's syringe into the recipient's vein until the donor's vein has been successfully punctured. The tourniquet is allowed to remain on the donor's arm throughout the entire transfusion, but its pressure frequently has to be varied in order to provide for complete compression of the vein with no interference to the arterial circulation. It is helpful to have the donor alternately clench tightly and open his or her hand during the entire transfusion. When the blood begins to flow into the operator's syringe, the assistant empties his syringeful of saline solution into the patient's vein. When the operator's syringe has been filled with blood, the stopcock is turned and this blood is forced rapidly into the patient's circulation, and the assistant now fills his syringe with blood from the donor. Thus the syringes are alternately filled and emptied until the transfusion is finished. The assistant is always doing exactly the opposite of what the operator is doing. The flow of blood should be plentiful and uniform, the syringes being filled quickly and unhesitatingly from the donor's circulation. As a rule, a 15 gage needle is used for the patient and a 13 gage for the donor, but this can be changed to suit varying conditions. When conditions are the best with blood flowing freely from the donor and with the largest needles inserted,

500 c.c. of blood can be, and frequently has been, transferred from donor to patient in two and one half minutes after the needles are in place.

The foregoing is a description of the technic when the apparatus is used in its double action capacity. When an assistant is not available, a few changes can be made to convert it into a single action apparatus. The services of a nurse or even a layman can usually be secured, and he or she can be instructed to introduce the saline solution through the recipient's side of the apparatus, to establish the fact that the needle is properly placed within the patient's vein. The criterion for this is absence of swelling around the end of the needle on the injection of saline solution. If the saline is being forced into the subcutaneous tissues, then the needle has passed completely through the vein or lies in some faulty position, of which there are several possibilities. No harm has been done as far as the ultimate success of the transfusion is concerned and another vein is selected, the site traumatized during the first attempt being watched for oozing of blood when the transfusion is begun. When the donor's vein has been entered and blood begins to flow into the operator's syringe, a plug is substituted for the assistant's syringe which contained the saline solution, and the transfusion proceeds as before, except that there is only one blood syringe in action.

If one is especially adept at venesection, the plug may be substituted for the assistant's syringe at the very beginning of the transfusion and the operator's syringe may be filled with saline solution and used for testing the position of the recipient's needle by simply turning the stopcock valve to the opposite side to that at which it is allowed to remain when the assistant's syringe is used for this purpose. When blood begins to enter the syringe, the transfusion proceeds as has been described.

When sufficient blood has been transferred, the needles are quickly removed, pressure applied until bleeding has stopped, and an antiseptic dressing applied quite tightly. This prevents subsequent bleeding through the puncture wound in the vein and a resulting ecchymosis. It is quite desirable to keep the donor lying down following the transfusion for a considerable time, varying with the condition of the donor in each case. The patient should be put to bed immediately, kept warm, and the appearance of a chill watched for. In the event of a reaction, heat should be applied, and our experience has been that the hypodermic administration of morphin minimizes reactions. The percentage of reactions in our cases, divided into separate series of 100 each, has ranged between 4 and 7 per cent., varying slightly with the different series. The reactions have all been mild. This is in marked contrast to the data from our series

of transfusions by the citrate method, following which the number of reactions was greater and the severity more marked.

Certainly the most difficult part of the whole technic is the introduction of the needles, and it is only with a little practice that it becomes easy. All intravenous work requires some skill, which varies with different individuals, as is observed when the withdrawal of a small amount of blood for laboratory tests is attempted with a fine needle. This difficulty in the transfusion technic is increased by the large caliber of needles necessary, but only a small number of failures should result if a little skill is combined with a little persistence. Success after a considerable number of attempts at entering the vessels by a needle through the skin is preferable to making an incision and exposing the vein, both because of the greater possibility of infection and the damage resulting.

It was necessary in this series to expose the vessel in four cases. Two of the patients were young children and two were women, both in a state of collapse. In one case, attempts to enter the recipient's veins failed. This patient was an infant who had reacted badly to the anesthetic during a tonsillectomy, and a transfusion was considered advisable. Entrance into the external jugular vein was attended with difficulty, but during the attempt the child's condition improved markedly and was no longer considered dangerous; so no incision or further attempt to give the blood was made. The child fully recovered.

A year ago, 1 per cent. procain solution was being injected intradermally at the site of the needle puncture through the skin. This is no longer done as a routine procedure for three reasons: A certain amount of pain accompanied the introduction of the hypodermic needle; the majority of patients and donors preferred to have their arms pierced only once and have it over with; and no anesthesia was provided for the subcutaneous and perivascular tissues and the blood vessel walls, which are quite sensitive and in which pain would be produced if any probing about became necessary. Besides infiltration of the tissues, even the skin obscures the field and adds difficulty to placing the needles properly.

It would not be proper to close this paper without a brief discussion of the methods of typing and the use of universal donors. Iso-agglutination occurs as the result of the presence in the plasma of isohemagglutinins or antibodies, and the presence in the erythrocytes of agglutinogens or receptors. When Jansky and Moss formulated the four groups into which the human blood falls, they believed that these four classes were made possible by the presence of two agglutinins and two agglutinogens, which were so distributed as to produce the occurrence of four blood groups. Other investigators later came to believe that while this classification was in the main correct and these were

the four principal groups, yet this classification was not strictly correct and that there were slight exceptions, as some expressed it, an "overlapping." It has been generally understood that individuals belonging to Group 4 possessed red blood cells which would not agglutinate when mixed with the serum or plasma of any individuals of any type. For this reason they could donate blood indiscriminately and were therefore designated as "universal" donors. It is not important from the standpoint of transfusing whether or not the more or less concentrated plasma of the donor agglutinates the patient's cells in vitro, because in an actual transfusion the donor's agglutinins would be diluted to such an extent by the blood of the recipient that their titer would be so weakened that they would no longer be capable of causing agglutination.

Unger [17] found that the serum of nine patients agglutinated to some extent the cells of Group 4 subjects. Six of these patients belonged to Group 4, one to Group 2, and in two instances the group was undetermined. He therefore drew the conclusion that there were "minor" groups. Levine and Mabee [18] found that in some instances more or less clumping was produced in cross agglutination tests by members of the same group, and expressed the belief that it was safer to employ direct matching than to use "universal" donors. Guthrie [19] and his co-workers surmised from their laboratory and clinical observation that there were at least three iso-agglutinins and three iso-agglutinogens and this they subsequently demonstrated to be true. Their discovery provided for the possibility of twenty-seven biologic combinations, eight of which they discovered at this time. They later showed that there are at least five iso-agglutinins and five iso-agglutinogens, which would lead to a huge number of possible combinations. They believe that some of these combinations are common while some rarely if ever exist. They also found that icebox temperature, or slightly higher, was the optimum for agglutination and also that, in some instances, as long a period as two hours was necessary to produce the slight amount of agglutination that furnished the confirmatory proof for some of their conclusions.

Schütz and Wöhlisch [20] state that iso-agglutination is an electrical phenomenon with which they have been able to interfere, in their

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17. Unger, L. J.: Precautions Necessary in Selection of Donors for Transfusion, J. A. M. A. **76**:9 (Jan. 1) 1921.

18. Levine, P., and Mabee, J.: Dangerous "Universal Donor" Detected by Direct Matching of Bloods, J. Immunol. **8**:425 (Nov.) 1923.

19. Guthrie, C. G., and Huck, J. G.: Existence of More Than Four Iso-Agglutinin Groups in Human Blood, Bull. Johns Hopkins Hosp. **34**:37 (Feb.) 1923; cont., **34**:80 (March) 1923; cont., **34**:128 (April) 1923.

20. Schütz, E., and Wöhlisch, E.: Blood Groups, Klin. Wchnschr. **3**:1614 (Sept. 13) 1924.

laboratory, by altering the physical environment and conditions under which the cells and serum or plasma exists. The work of Ottenberg [21] dealing with the hereditary factors concerning blood groups has been based entirely on the existence of only four groups. In this series of transfusions, it has been possible to make valuable observations from a clinical standpoint. Donors for essentially all these transfusions were intentionally selected from information derived by indirect testing only. They were used because they belonged to the same group as the recipient or because they were in Group 4. In 1,000 consecutive transfusions, 84.6 per cent. of the donors were in Group 4 regardless of the type of the patient. In this 1,000 transfusions, 57 per cent. of the patients belonged to groups other than Group 4, and for these 570 patients 73 per cent., or 426, of the donors belonged to Group 4, or, in other words, were "universal" donors. All these transfusions were performed by the whole blood method. There were no serious reactions. Furthermore, the percentage of reactions was essentially no higher in the 73 per cent. of transfusions given to 570 Groups 1, 2 and 3 patients, for which universal donors were used, than in the remaining 27 per cent., in which donors corresponding to the patient's group were used. And likewise in the whole 1,000 cases, the percentage of reaction was nearly exactly the same in the 84.6 per cent. in which Group 4 donors were used as it was in the 15.4 per cent. in which the patient and donor belonged to the same group.

There has been considerable controversy regarding the advisability and permissibility of transfusing infants within the first few days after delivery without regard to the type of blood given. It has always appeared that the typing of the blood could be dispensed with in such instances. Recent investigations by de Biasi [22] have shed additional light on this subject. He has shown two things: First, that in a series of 100 cases of newly born infants all possessed receptors, as demonstrated by the fact that a type could be found for all of them and that all could be classified according to group. In the second place, he demonstrated by actual transfusion that the mothers in every instance could act as donors for their babies without regard for any test as to compatibility. The serum of none of these infants would agglutinate the cells of the mother. The inference was naturally drawn that the cells of the mother would not agglutinate when mixed with the serum of her young child because of a certain immunity or resistance developed

21. Ottenberg, R.: Hereditary Blood Qualities; Medico-Legal Application of Blood Groupings, J. Immunol. **6**:363 (Sept.) 1921.

22. De Biasi, B.: Iso-Agglutinins in Blood of New-Born, J. A. M. A. **81**: 1776 (Nov. 24) 1923.

on the part of the mother's cells against any agglutinating action which could be exerted by the agglutinins in the infant's serum. It would seem more nearly correct to believe that the reason such agglutination did not take place at that early date was that no agglutinins whatever had developed in the serum or plasma of the child. In other words, the agglutinogens develop before the agglutinins make their appearance.

It was formerly incorrectly believed that the agglutinins developed first and the reason that we did not have auto-agglutination taking place was that the red cells became immune to the action of the agglutinins with which they were associated. The conclusions of de Biasi could probably be extended so that it would be safe to say that not only mothers but any one else could give blood to an infant only a few days old because they are virtually "universal" recipients.

COMMENT

Aside from the arguments concerning the value to the patient of citrated or unmodified blood, the citrate method has frequently been pointed out as superior because of the ease and convenience with which it can be carried out, the absence of clotting, and the lack of necessity for dissecting out and exposing the veins. None of the advantages attributed solely to the citrate method are not possessed by the method for transfusing unmodified blood which has been described in this article. This direct method is as simple, there is no clotting when properly executed, and there is no need for exposing veins more frequently than when using the citrate method. In addition it possesses the advantage of greater speed. Two or three transfusions by this method can frequently be performed while one citrate transfusion is being given.

The fact that the donor does not need to be in the vicinity of the patient is not an advantage.

The variable and uncertain interval of time elapsing between the drawing and the giving of the blood by the citrate method, an hour or more in some instances, is undoubtedly a factor in the production of posttransfusion reactions. It is highly possible that undetermined changes which take place in the blood during its sojourn outside the blood vessels might partially explain the greater instances of reactions following the administration of citrated blood. Luney's [23] remarks probably contain considerable logic when he says that reactions are at least to some extent due to the slow collection of the blood resulting in early coagulative changes, to chilling of the blood, to exposure to the air, and to undue manipulation and agitation.

23. Luney, F. W.: A Citrate Method of Blood Transfusion Devised to Minimize Posttransfusion Reactions, Canad. M. A. J. **13**:587 (Aug.) 1923.

Bacon [24] states that the paraffin tube method of Kimpton and Brown is superior to the Unger type of apparatus because with the latter more time is required to give a transfusion and so speed is sacrificed, that clotting is a greater factor, and that it is more difficult to handle the patient when using this method. In our experience, the reverse is true in each instance. The same writer also believes that the ligation of veins is a small matter and that an individual rarely receives more than one transfusion in a lifetime. Four patients in this series received between ten and thirty-six transfusions and a number of donors we have used have donated more than twenty times, an impossible feat if ligation of veins was practiced.

The experimental work on iso-agglutination and isohemolysis has been voluminous, but many of the conclusions and results from animal and laboratory experimentation do not find practical application and are not substantiated by actual clinical experience. It is in the clinical results that we are of necessity more deeply interested. Better results could be obtained in transfusion work if more careful attention were paid to the technic of grouping in the laboratory and to the quality of the reagents used. Typing serums deteriorate after variable periods of time, some rather soon, while others may last for months if properly preserved. Some typing serums deteriorate suddenly, so that it is possible for them to possess adequate potency and a high titer today and be absolutely valueless tomorrow. Some laboratories perform a large number of these tests while others perform very few, and for this reason some laboratories renew their serums frequently and maintain a close familiarity with their value, while others use serums of considerable age and are uncertain as to their potency. More care along this line is urged. We find that a very valuable check on the agglutinating power of our Groups 2 and 3 serums can be furnished by the additional use of Group 4 serum, which is obtained fresh every three or four days or oftener. Deterioration of either Groups 2 or 3 serums can usually be detected by this means because when agglutination has been produced by the Group 4 serum and not by Groups 2 or 3 serums, the reason is that one of these has deteriorated.

In answer to a question frequently asked, it may be said that there is no evidence that an individual's blood group ever changes. There are occasional instances when it would appear that this is not true. But on careful investigation, it is usually found that, when the individual is found to be in one group at one time and in another group at another, there was an error in one of the two tests. Or the individual may be a victim of the confusion resulting from the existence of more than one

24. Bacon, D. K.: Choice of Method in Blood Transfusion, Minnesota Med. 7:725 (Nov.) 1924.

classification. While the Moss classification seems to be the most popular in all parts of the world, I believe the Jansky is the more authentic, owing to its priority and because it has been officially adopted by the American Association of Immunologists and by the American Association of Pathologists and Bacteriologists. There is no authentic instance, to my knowledge, of an individual's group having changed.

CONCLUSIONS

1. A modification and improvement of the apparatus formerly used has still further simplified the technic of administering unmodified blood, i. e., blood that has been undiluted, untreated and unchanged in any manner.

2. This change in the apparatus has halved the time actually necessary to transfer the blood from the donor to the patient, and consequently practically doubled the efficiency of the method, and has provided a technic that probably cannot be materially improved.

3. The cases in which it has been necessary to expose the vein have been less than 0.5 per cent.

4. There have been no failures, i. e., cases in which the transfusion could not be performed.

5. The burden of proof demonstrated by this series of cases and substantiated by the majority of workers unquestionably favors the whole blood method.

6. While it is not possible to make determinations that are quantitatively exact, clinical observations furnishing the only possible conclusions, there apparently have been no greater incidence of post-transfusion reactions when "universal" donors were used than when the donor and the recipient belonged to the same group, disagreeable reactions having been nil in all cases.

7. The apparatus, which is devoid of intricate mechanism, requires the minimum of assistance to operate, it can be operated by one individual if necessary, and is adapted to unfavorable working conditions and to operation in small quarters, such as are frequently encountered in the patient's home or in hospital rooms.

2201 East Jefferson Avenue.

THE TRANSFUSING OF UNMODIFIED BLOOD

III. THE CLINICAL ASPECT OF ONE THOUSAND CASES *

ALEXANDER W. BLAIN
AND
OSBORNE A. BRINES
DETROIT

This article is presented as an informal review of certain experiences and impressions received and observed in 1,000 transfusions by a whole blood method, the technic of which is described by one of us [1] elsewhere.

Blood transfusion belongs to the newer advances in medicine and surgery. No therapeutic agent is more specific than transfusion to supply deficiency and replace loss of the circulating medium of the body. Transfusion is no longer a physiologic experiment, its success depending on the gymnastics of blood vessel surgery. It is proper that such a valuable procedure as the transferring of blood from one person to another, with all its attending possibilities, should receive both attention and popularity. Like other novel procedures designed for the treatment of the sick, blood transfusion, owing to insufficient investigation, unsatisfactory understanding and fertility of the imagination, has been the cause of false hopes and dreams. It is our duty in choosing a remedial agent to study and appreciate this as well as other recent medical innovations, and by careful observation and analysis to balance the advantages against the disadvantages.

Often a certain procedure that seems to possess startling value at one time may act as a two-edged sword at another. Rather than allow enthusiasm to gain mastery over judgment, it is well to stop and analyze conscientiously to determine, with as much exactness as possible, where our treatment might possibly be beneficial and where it could not possibly be productive of good results. To be sure, we wish to give our patients the benefit of anything that will produce favorable results; yet we do not wish to subject them to superfluous and unnecessary treatment. So it is necessary when we are considering things that border on the spectacular to keep our feet on the ground.

EVOLUTION OF METHOD

It has been both interesting and gratifying to watch direct transfusion evolve in the last five years from an experimental procedure

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* From the Jefferson Clinic and Diagnostic Hospital.

1. Brines, O. A.: Transfusing of Unmodified Blood, Arch. Surg. 7:306 (Sept.) 1923.

associated always with a certain degree of uncertainty and a varying degree of success, a procedure to be used only in the most favorable cases, to a method of superiority which is safe, rapid and reliable in all cases. At first children and the extremely sick patients—patients unable to be brought to the operating room—were eliminated from its use. Formerly, whenever a direct transfusion was contemplated the citrate apparatus was always in readiness to be resorted to in case of failure. In the last three years we have not used, or even considered using, the citrate method in any case, and we have never had the uncomfortable experience of being unable to give blood to any patient by the whole blood method. It seems quite obvious that the direct method is just as applicable to difficult cases as the citrate method because any difficulty that might arise usually involves the introducing of the needles, and once this has been accomplished the blood can be given more quickly and with greater benefit to the patient by the direct method.

A feature of the citrate method which undoubtedly appeals to many is that the blood may be transported from the place at which it is convenient to withdraw it from the donor to the bedside of the patient. We have shown repeatedly that when a considerable length of time is allowed to elapse between the withdrawing and injecting of the blood, changes take place rendering blood, otherwise compatible, now more or less incompatible, the result being a mild or even severe reaction. This phenomenon is undoubtedly only a contributory factor in the high incidence of reactions following the giving of citrated blood, because, regardless of the length of time that the blood remains outside the blood vessels, some change takes place which is undesirable. So the injury to the blood is undoubtedly brought about on one hand by a chemical agent, sodium citrate, and on the other hand by physical influences, such as agitation, chilling and exposure to the air.

We have never been confronted by a situation in which it was impossible or even undesirable to have the donor lie down beside the patient. In the hospital room or ward, satisfactory operating room conditions can easily be simulated. One famous surgeon of this country does part of his thyroid surgery in the patient's room. At times it seems desirable to perform the transfusion at the patient's home, and while in the majority of cases satisfactory arrangements can be made, there are occasional instances in which at first glance the situation looks hopeless. By the application of a little resourcefulness and ingenuity a makeshift arrangement that is workable can be instituted, however. At least there has been no instance in our experience in which the proper provisions could not be made, although added inconveniences make the work more difficult.

INDICATIONS FOR TRANSFUSION

In discussing indications for transfusion, the various anemias may be passed over rather quickly. It is not difficult to understand the logic of supplying a substance from which the body is suffering a conspicuous lack, or of replacing a substance that it has recently lost, providing such a thing is possible. And in this case it is easily possible. The results of transfusion in anemia resulting from exsanguination are practically 100 per cent. successful. Here poor judgment is frequently exercised. In the first place there is often delay in deciding to give the transfusion, or too much time is consumed in making the necessary preparations. For patients who have suddenly lost a large amount of blood from hemorrhage, the transfusion should be done almost immediately and the quantity of blood given should nearly, or somewhat roughly, approximate the amount lost. This is most particularly true in the first few hours after hemorrhage, but often transfusions performed in this brief interval supply only a small quantity of blood, perhaps 500 or 600 c.c., when probably 2,000 or 3,000 c.c. were actually lost.

Mayo [2] has called attention to the advisability of giving repeated small transfusions in extreme hemorrhage rather than a single large one, provided the first one was large enough to maintain life. His views are probably more applicable to cases in which several hours have elapsed after the loss of blood occurred. We cannot help but believe that, in cases suffering from extreme and sudden exsanguination, time is an important factor, because if the exsanguination exists for more than a few hours permanent degenerative changes occur in several organs. In restoring as completely as possible at this early period the amount of blood lost, we are going a long way to prevent a serious condition of shock and acapnia.

Transfusion in pernicious anemia serves only as a palliative treatment. We find reports on the one hand of marked success, and in some instances apparent cure, from transfusion in this condition; and on the other hand there are those who tell us that no benefit is derived. In our series of cases, we have illustrations of both extremes. Unless the case has practically reached the terminal stage, the average patient with pernicious anemia responds quite nicely to transfusions, and there are a number of patients whom we have observed to receive several months, and even two or three years, additional life as the result of transfusions. One case of pernicious anemia in particular illustrates quite forcibly the good results that may be derived from transfusion. This patient, a school teacher, has received a transfusion every two or three months,

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2. Mayo, W. J.: Certain Blood Dyscrasias Dependent on Pathological Conditions of the Spleen, J. A. M. A. **83**:11 (Sept. 13) 1924.

and has been doing so for the last two years. She usually insists on waiting each time until she is confined to her bed. On two occasions she was transfused when practically comatose, her hemoglobin having been as low as 17 per cent. Four or five days following nearly all the transfusions, she was sufficiently improved to live quite a normal existence, and has even taken motor trips of several hundred miles and for a period resumed her duties as school teacher. We have many times thought that a certain transfusion would be the last, but her condition is greatly improved over what it was when she received her first transfusion two years ago. It has been our experience that patients with pernicious anemia react better when transfused at intervals of from one to three months, than when transfused frequently, for instance, every week or ten days.

A ward walk through any hospital reveals many patients who are unmistakably anemic, and if the hemoglobin of these patients were estimated it would be found to fall around 50 per cent. With the majority of patients this condition is of long standing. A long extended use of iron or arsenic would probably slowly improve the blood picture. In some instances, we have found that it was impossible to increase by the use of drugs the number of red cells in patients suffering from secondary anemia, possibly following an extended infection, even after the cause of the anemia had been removed. At any rate the results were discouraging. For these patients it is possible, in many instances, to accomplish more in a few minutes with a blood transfusion than in several months of drug treatment. The correcting of a secondary anemia is often the only step necessary to change the so-called invalid into an individual capable of enjoying life as a useful member of society.

Blood transfusing is finding extensive use in the hands of various workers in infections. It is somewhat difficult to demonstrate in a clear-cut manner the effect of transfusions in this connection, yet there can be no doubt that transfusing lowers the mortality and raises the resistance to sepsis. Stetson,[3] after carefully analyzing a hundred cases, concludes that septic cases should be transfused early and the operation repeated every forty-eight hours until the blood cultures are negative, or until the clinical condition of the patient warrants the discontinuing of the procedure, and he expresses the belief that for the patient who can escape pneumonia or meningitis, blood transfusion improves the chances of recovery 50 per cent. Cross[4] transfused a considerable number of patients with erysipelas and had no mortality.

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3. Stetson, R. E.: Therapeutic Value of Blood Transfusion, Am. J. M. Sc. **168**:534 (Oct.) 1924.

4. Cross, G. K.: Blood Transfusion in Children, Brit. J. Child. Dis. **21**: 173 (July-Sept.) 1924.

In a series of equal size for which transfusion was not employed, the mortality was 9 per cent. We find that the principal reason better results are not secured in transfusion for infection is that the patient is moribund when the transfusion is decided on. Colebrook and Storer [5] find that whole blood possesses bacterial properties for streptococci and staphylococci. We have followed that thought in our treatment of infections in that we generally transfuse for coccoidal infections and resort to the intravenous administration of dyes, such as mercurochrome-220 soluble, in bacillary infections. There may be doubt in the minds of some if blood really does possess bactericidal activity. Many bacteriologists have observed the bactericidal effect of blood in blood cultures with a resulting difficulty of obtaining positive findings. So today in a number of laboratories, steps are taken to inhibit this bactericidal activity by the addition of some substance, such as trypsin, with a resulting increase in the number of positive cultures.

VARIATIONS IN TECHNIC

Slight variations in the technic of transfusions is encountered in the treatment of infections. There are those who accompany the transfusion by venesection, the procedure being referred to as exsanguination transfusion. The object is to remove toxins or poisons from the body and to supplant the blood removed with new blood of good quality. This procedure would doubtless be commendable in cases of drug or chemical poisoning, yet in infections we would be fearful lest we throw away some of the valuable defense substances of which the patient is so badly in need. Robertson [6] has used exsanguination transfusion successfully in severe burns, and there are instances reported in which it appeared to be valuable in cases of carbon monoxid poisoning.

With immunotransfusion we have had no actual experience except with unmodified whole blood. Attempts have been made to raise the opsonic index by adding a killed suspension of the appropriate organism to the blood after it has been drawn from the donor and either citrated or defibrinated and then incubated. Defibrination is superior to citration from a standpoint of chemical damage done, and yet in defibrination such a large number of white corpuscles are removed that this advantage is overcome. The good results derived from transfusion in infection

5. Colebrook, L., and Storer, E. J.: On the Reduction of the Bactericidal Power of Blood Which Is Effective by Adding to It Citrate of Soda and Other Decalcifying Agents; and on the Question of Whether Blood so Treated should Be Employed for Immunotransfusions, Brit. J. Exper. Path. **5**:47 (April) 1924.

6. Robertson, L. B.: Exsanguination Transfusions, Arch. Surg. **9**:1 (July) 1924.

are probably largely dependent on the action of the new leukocytes administered.

Unmodified blood is a valuable agent in reducing the clotting time. Crile [7] believes that whole blood is the most valuable hemostatic substance we have, more valuable than calcium salts or the lactates, and is indicated whenever we wish to improve coagulation. In discussing certain types of hemorrhage and most particularly those of the gastro-intestinal tract, the opinion is often advanced that a transfusion would raise the blood pressure and increase the liability of bleeding. We have found that in such cases blood transfusion was the most valuable weapon at our disposal for controlling bleeding of the mucosal surfaces. In every case under our observation in which there was bleeding from the stomach or intestine due to ulcer or ruptured varix, the bleeding was immediately stopped by the administration of whole blood, and in some instances bleeding did not recur. Patients having purpura with extensive bleeding should receive large quantities of blood, often as high as 2 or 3 liters, and in these cases it is essential that the blood be untreated by chemicals.

USE IN SURGICAL CASES

The rationality of transfusion in the more difficult major surgical cases is easily seen. Many patients come to operation weak, starved and anemic. The condition of many of these involves chronic bleeding, malignancy or chronic infection. The resistance of these patients is low, their convalesence usually slow, and they are bad surgical risks. Transfusion before or following operation, or at both times, improves the blood picture, the general condition, and the prognosis of the case. Then there is the loss of blood at operation which Gatch and Little [8] have shown to be often larger than the surgeon suspects, at times 600 and 700 c.c. or even more. A normal, healthy person can lose that much blood without consequence, but a person more or less severely ill, subjected to the shock of an operation and a prolonged anesthetic, can ill afford to lose that much.

There is a large class of patients, particularly surgical patients, who simply do not convalesce properly following operation. It is difficult to make a concise analysis of the situation. There is apparently nothing particularly wrong with the patients, and yet they lack something. We transfuse these patients and we often bring about a marked change. Their appearance, their condition, and the whole situation is changed, and they begin to convalesce rapidly and at once. We do not know what

7. Crile, G.: Personal communication to the authors.

8. Gatch, W. D., and Little, W. D.: Amount of Blood Lost During Some of the More Common Operations, J. A. M. A. **83**:14 (Oct. 14) 1924.

change has taken place, we cannot explain in terms of biochemistry what we have done, and yet no one can deny that we have lessened the morbidity of that patient and improved the chance of recovery. The process of a patient's recovery is very frequently not under the control of the physician, and he is only too often perfectly helpless in changing the course of the disease. Many patients overcome their disease not as a result of what the physician does for them but because the natural tendency of any deranged metabolism or disturbed physiologic balance is to return to normal. In other words, the patient will frequently get well if he lives long enough; so many times the sole reason for giving a transfusion is to tide the patient over until he can mobilize his own defense forces and thereby gain mastery over the situation.

SEQUELAE

Our experience with transfusion has been for the most part satisfying, and the results have been gratifying, but the good is punctuated now and then with a few undesirable results. Medical men, as a rule, hesitate to report unpleasant instances. However, these unpleasant experiences in blood transfusion are becoming markedly reduced. Prior to 1920, the reported deaths from transfusion while rare were not at all unheard of, while in the last few years the writers were able to find the report of only one fatal case,[9] a typical death from anaphylaxis. The marked reduction in mortality, which is now practically zero, together with the knowledge that blood transfusion is continually becoming a more commonly used procedure should be a stimulation to the pride of the profession. This improved condition of affairs is undoubtedly due largely to the greater scrutiny and improved methods of the laboratory people who make the preliminary compatibility test.

In none of the cases which either of us have observed do we know of an instance in which a transfusion was a direct cause of death. Several years ago a patient under treatment at this clinic was given a transfusion for secondary anemia. This patient had previously been under treatment for chronic nephritis. Following the transfusion the patient became exceedingly "neurotic" and quite irrational. The patient did not speak English well, and when the history was taken a previous mental condition was not recorded. The patient complained of nausea and vomited even water, especially on suggestion, and so for several days the fluid intake was very small. There was then an exacerbation of the nephritic condition, oliguria, and finally anuria, and death ensued.

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9. Carrington, G. L., and Lee, W. E.: Fatal Anaphylaxis Following Blood Transfusion, Ann. Surg. **78**:1 (July) 1923.

An analysis of this case convinces us that the recurrence of urinary symptoms was dependent on the small fluid intake failing to provide sufficient water to flush the catabolic products out of the kidney. We did not force fluids, which may have been a mistake, and possibly another transfusion might have been the proper treatment. A decapsulation of the kidney was not done to relieve tension because past experience had not shown this procedure to be especially beneficial. This case is mentioned because it might be possible that the transfusion was a contributory cause of death.

Bancroft [10] reports a similar case in which a double decapsulation of the kidneys improved the patient's condition. Bowers and Trattner [11] report a case of acute nephritis with anuria. Decapsulation of the right kidney was performed, which was followed by no improvement. They then performed four venesection transfusions, drawing and injecting 500 c.c. at each time, following which the patient recovered. In such a condition, a venesection transfusion is undoubtedly preferable to an ordinary transfusion because the object is to detoxify the circulation, and we are not especially interested in the conservation of antibodies. Martin [12] believes that blood transfusion is the best of all diuretics in oliguria, with impending anuria, when it is possible that the anuria is due to low blood pressure from toxemia. But unless such a condition is complicated by anemia, it would seem advisable to attempt treatment consisting of the administration of fluids and drug therapy before resorting to transfusion. We would not expect good results from transfusion for patients with acidosis, and it is possible that here there would be contraindication.

Acute dilatation of the heart is a much talked of sequel of transfusion but one which we, fortunately, have not observed. It is, however, a complication well worth bearing in mind. There is still doubt as to how much the blood pressure rises or falls following the injection or taking away of a given amount of blood. This is probably because there are a number of contributory factors involved and different individuals present varying reactions. It can probably be said that, following the injection of 500 c.c. of blood, the blood pressure rises from 10 to 15 mm. In some cases the rise in blood pressure is hoped for and in others it is detrimental, so it is sometimes important to know how much of a rise or fall to expect. One patient about to receive a transfusion had a sudden dilatation, and had it occurred a

10. Bancroft, F. W.: Proc. South. S. A., J. A. M. A. **84**:142 (Jan. 10) 1925.

11. Bowers, C. A., and Trattner, H. R.: Repeated Venesection Blood Transfusion in Anuria, Surg., Gynec. & Obst. **39**:229 (Aug.) 1924.

12. Martin, R. P.: Transfusion of Blood in Urology, Siglo méd. **73**:615 (June 21) 1924.

few moments later the transfusion would have received the blame. In transfusions, as with all therapeutic methods, it is not always possible to attribute success or failure to the treatment, and for that reason we have always tried to be conservative lest we give more credit to blood transfusions than the procedure actually deserves.

Air embolism is believed by many to be merely a joke and something that does not exist. Many of us have acquired such views as the result of animal experiments in which it has been possible to inject large quantities of air into the circulation without producing serious results. In a personal communication, our attention has been called to a case in which, following the injection of about 3 c.c. of air into the vein, the patient died immediately. While this case was undoubtedly quite an exception, we feel that it is a warning and would advise against the injection of any appreciable amount of air along with blood. To the best of our knowledge, embolism has never been produced in any of our transfusions. In one case there was an oozing of blood from the puncture wound of the vessel producing an extensive ecchymosis in the vicinity of the elbow, which caused temporary interference with circulation to that extremity. Sufficient absorption to allow a restoration of circulation was soon effected by the application of heat. This incident has taught us the necessity of tight bandaging about the area of the puncture, and an observance of this custom has prevented further trouble.

EFFECT ON DONORS

We must not forget that the donor is an important part of the blood transfusion, and we must assume a certain amount of responsibility for his or her welfare. We are frequently asked if donating blood is harmful, and our answer is that we do not know. There are possible instances in which a venesection is beneficial, and yet it is doubtful if the average individual is benefited by a loss of blood. The loss of 700 or 800 c.c. of blood rarely produces a noticeable effect on the average person. Regarding the frequency with which individuals can give blood, our opinion is that there is great variation with different subjects. Some of our "professional donors" seem to have an unlimited supply of blood and marked powers of regeneration, and these people can be used a large number of times and at frequent intervals without any marked change in their hemoglobin percentage or their general condition. Others are much more easily affected. After a transfusion, some donors feel no different from what they did before, while others always find it necessary to remain quiet for a considerable time afterward. A donor who was used quite recently for the first time gave 400 c.c. of blood, which was removed rather slowly. In attempting to

walk from the table to the bed a few feet away, he fainted and remained unconscious with a pulse that was barely perceptible for twenty minutes. During the transfusion he did not appear frightened, nor in any way affected. This incident is mentioned because it is quite unusual. The maximum amount of blood taken from any one donor by us at one time was 1,400 c.c. Different donors have contributed practically this much at various times without any noticeable after effects. The largest amount of blood given to a single patient at one time in this series was 2,600 c.c. This amount was contributed by four donors and the flow of blood into the patient's circulation was practically continuous, the needle in the patient's vein not being removed when the donors were changed. When considering the giving of several transfusions, it is well to realize that the rise in hemoglobin following one transfusion of from 500 to 700 c.c. is usually from 15 to 25 per cent.

COMMENT

Blood transfusion is a valuable adjunct to medical and surgical treatment, and our patients should be given full benefit of all that it holds for their welfare. Transfusion in many instances constitutes only part of the regimen of good treatment. For instance, we transfuse nearly every toxic goiter case before operation, but that is only part of the story, the remainder of the treatment being subcutaneous administration of from 2,000 to 4,000 c.c. of procainized sterile saline solution in twenty-four hours, sedatives, careful nursing by well fitted nurses, the use of compound solution of iodin before operation, and perhaps ligation. We have found that transfusion is a valuable asset before and after serious major operations, such as those for goiter, hysterectomy, gallbladder removal, nephrectomy, resections of the stomach and intestine, leg amputations and operation for ectopic pregnancy. In fact, it is valuable in any surgery involving extreme shock, when the patient's general condition is poor, when there has been considerable loss of blood, and when the patient is above middle age.

We believe that the reinfusion of blood from an abdominal, vaginal or any other kind of hemorrhage is not advisable. No blood should be administered unless it has been freshly and directly removed from the circulatory system. And again it seems that, in regard to administering blood intraperitoneally, it would be better to put it in the proper place, and that is into the circulatory system.

CONCLUSIONS

1. The transfusing of unmodified blood is a safe procedure and one of extreme benefit to the patient in a variety of conditions. The most conspicuous of these are the various anemias, infection, hemophilia,

purpura, and in those surgical cases in which, owing to some nonspecific or unexplainable effect, the patient's condition is undeniably improved.

2. For best results transfusions should be performed early, a sufficient quantity of blood given and the transfusion repeated several times if necessary. When in doubt as to whether a transfusion should be performed, it is better to decide for it.

3. There is much regarding the subject of transfusions that cannot be explained in the experimental laboratory. The most valuable information that we possess has been accumulated at the bedside of the patients, and as a result of observing clinical results, which, though not quantitatively exact, serve us well in the appreciation and interpretation of results obtained.

4. The results obtained justify our effort to encourage others to avail themselves of the advantages that blood transfusion offers for extremely sick patients.

2201 East Jefferson Avenue.

TWENTY-EIGHTH REPORT OF PROGRESS IN ORTHOPEDIC SURGERY*

ROBERT B. OSGOOD, M.D.; NATHANIEL ALLISON, M.D.
PHILIP D. WILSON, M.D.; HERMAN BUCHOLZ, M.D.
ROBERT SOUTTER, M.D.; HARRY LOW, M.D.
MURRAY S. DANFORTH, M.D.
LLOYD T. BROWN, M.D.
AND
M. N. SMITH-PETERSEN, M.D.
BOSTON

CONGENITAL CONDITIONS

Congenital Dislocation of the Hip.—Certain rather interesting observations have been made in two series of end-result studies of reduction of congenital dislocation of the hip. One study is by Ely[1] of seventeen cases in which the Lorenz method was employed. Nine, or a little over 50 per cent., of these cases were successful. Ely believes that if the first attempt to reduce fails a second attempt is rarely successful. Open operation showed that the failure was due to a constriction of the capsule with or without adhesions of the head, or to the internal twist of the neck and head on the shaft of the femur. In his series, deformities of the acetabulum were not important.

The second series of 349 cases in private practice is reported by Chatterton and Flagstad,[2] and in these Ridlon's method of reduction was employed. About 85 per cent. of perfect functional results were obtained in these selected cases. In the majority, however, roentgenograms revealed distortions of the acetabulum, head and neck, and there were very few in which the anatomic structure of the acetabulum and femur were normal.

[ED. NOTE.—We agree with Ely that constrictions of the capsule and torsions of the femur are the main factors that militate against successful permanent reductions by any closed method. We are surprised that he considers the acetabular changes of little importance. The varying depth of the socket and the varying obliquity of the upper

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* This report of progress is based on a review of 296 articles selected from 554 titles dealing with orthopedic surgery, appearing in medical literature between April 1 and July 1, 1925. Only papers that seem to represent progress have been selected for note and comment.

1. Ely, L. W.: Congenital Dislocation of Hip, J. A. M. A. **84**:1627 (May 30) 1925.

2. Chatterton, C. C., and Flagstad, A. E.: J. Bone & Joint Surg. **7**:355 (April) 1925.

rim or shelf as shown by stereoscopic roentgenograms in the Lovett-Soutter series [3] have seemed to us to play an important part in the stability of the reduction. We also are convinced that the observations of Chatterton and Flagstad as to the subsequent deformation of the joint in the majority of the cases will be confirmed by the study of any series of cases of more than five years' duration. No closed method of successful reduction with which we are familiar seems to escape these important changes. We shall await the results of Galloway's open reductions with interest.]

Allison [4] calls attention to the advantages of the two stage operation in reduction of congenital dislocation of the hip in young adults, reporting two successful cases. At the first operation all contracted structures are divided and skeletal traction is applied. At the second operation when the head has been pulled down its replacement in the acetabulum is accomplished.

Sacralization of the Fifth Lumbar Vertebra.—Moore [5] has examined 1,104 roentgenograms of the lumbosacral region taken for various conditions, has studied clinically, anatomically and roentgenographically eighty-seven cadavers and skeletons, and has observed forty patients with known sacralization of the fifth lumbar vertebra. He concludes that in about 3.5 per cent. of all people a sacralization exists; that in about 50 per cent. of the cases symptoms associated with its occurrence may be found but that although these symptoms may be related to it they are by no means always accounted for by the abnormality alone.

[ED. NOTE.—In our combined experience we have thus far never found it necessary to fix operatively or to remove the offending sacralized transverse process, and we believe that our patients have been relieved of the low back and nerve pressure symptoms for which they sought treatment. This belief has been permanent when these patients have observed the simple and nonhandicapping precautions indicated.]

RICKETS AND DEFICIENCY DISEASES

Causation and Prevention of Rickets.—Webster and Hill,[6] after a review of their own experimental evidence and a study of the literature, conclude that a low calcium and inorganic phosphate level in the circulating blood due to defective absorption from the intestinal canal is suggested as the primary cause of rickets.

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3. Soutter, Robert; and Lovett, R. W.: Congenital Dislocation of Hip, J. A. M. A. **82**:171 (Jan. 19) 1924; abstr., Internat. Survey Surg., March, 1924, p. 433.

4. Allison, Nathaniel: J. Bone & Joint Surg. **7**:330 (April) 1925.

5. Moore, B. H.: J. Bone & Joint Surg. **7**:271 (April) 1925.

6. Webster, A., and Hill, Leonard: Brit. M. J. **1**:956 (May 23) 1925.

Body Fluids in Rickets.—DeGennes [7] found in thirty-four rachitic infants aged from 2 months to 2 years, the slightly lowered calcium content of the blood that suggests active rickets. When these patients were irradiated the normal calcium level was rapidly reached. In the children with developing rickets and bone lesions there was a constant reduction in the phosphates of the blood, sometimes to one-half the normal, while in old established rickets the phosphate as well as the calcium concentration was normal. In children in whom the fixed concentration of the inorganic phosphates had been determined, a rapid and constant increase in the concentration resulted from exposure to a 1,200 candle power arc lamp at 0.8 mm. or to a 3,000 candle power quartz lamp. The maximum concentration was reached in about fifteen days and was sometimes temporarily above normal. The calcium elevation was not always parallel to the phosphorus but apparently could not take place without it.

Irradiation of Milk and Healing of Rickets.—Cowell [8] found that following out the suggestion that rat food known to be deficient in fat soluble vitamin became "activated" if exposed to ultraviolet light, the same effect could be shown in children by irradiating the children's food. In his experiments two children were given milk that had been irradiated, and one child milk that had not been so treated. The effects were followed with roentgenograms that showed definitely that in the two children fed with the irradiated milk a more dense calcification, much in excess of what one would expect to have occurred in so short a time, had taken place as the result of the administration of this irradiated diet.

[Ed. Note.—This small series is suggestive and seems to warrant further observations.]

Antirachitic Activation of Foods and of Cholesterol by Ultraviolet Irradiation.—Hess [9] considers it an established fact that foods as well as cholesterol and phytosterol which are found in all cells (the former in animal, the latter in vegetable cells) can be endowed with specific antirachitic potency by exposure to irradiation. This demonstrates that there is a definite physiologic process by which ultraviolet rays can bring about a change in the tissues. It furnishes a chemical basis for interpreting the effects of heliotherapy. What may be the relation of this activation of cholesterol to the broad problem of the nature of vitamins depends largely on our definition of a vitamin. At present the definition is so vague and varied that it would be futile to consider

7. DeGennes, L.: Bull méd. **39**:121 (Jan. 31) 1925.

8. Cowell, S. J.: Brit. M. J. **1**:594 (March 28) 1925; abstr., J. A. M. A. **84**:1456 (May 9) 1925.

9. Hess, A. F.: J. A. M. A. **84**:1910 (June 20) 1925.

whether or not a vitamin has been formed by means of irradiating cholesterol. All that can be definitely stated in this connection is that a chemical substance that is ubiquitous in the cells of the body can be rendered specifically curative as a result of exposure to ultraviolet radiations, and that a minimal amount—less than 1 mg. a day of this activated substance—suffices to protect experimental animals from the lesions of rickets.

Garland [10] presents a good report of the progress and knowledge of rickets to date. From the practical point of view the following facts are important: Neither human milk nor cow's milk will protect the growing infant from rickets. The ultraviolet lamp, the direct rays of the sun, cod liver oil and egg yolk will protect. The ultraviolet lamp is rarely available for a large number of infants; the sun's rays are often unavailable; cod liver oil and egg yolk are practically always available, and some of these agents should be employed daily, at least, after the first month of life. Cod liver oils may vary in their potency and an oil of known value should be used. Three drams (11.2 c. c.) a day is not a large dose for a young infant and in premature cases it might be well to supplement this with calcium and phosphorus. When rickets is complicated by tetany the antirachitic treatment should always be supplemented by calcium chlorid or hydrochloric acid for the immediate relief of symptoms. Little fear need be felt concerning the infant's ability to digest the added fat for Deuel and Holmes have shown its coefficient of digestibility to be ahead of any other oil so tested. In cases in which it does not seem to be well borne egg yolk may be substituted. There is already some evidence that application of cod liver oil by inunction may be efficacious.

Deficiency Diseases.—Van Nuys [11] has made an excellent study of the old and recent literature of the science of nutrition. The three well recognized vitamins, a doubtful fourth, and probably several others undiscovered as yet, are discussed as to the place they fill in plant and animal life. After this he takes up the question of the proteins that by the action of digestive ferments are broken up into amino-acids, the real factors of protein metabolism. The body cell selects those amino-acids it needs and discards the rest. The unused amino-acids are burned in the body as fuel exactly as are the fats and carbohydrates. Proteins vary so greatly in physiologic value that Lusk suggests that we classify them as A, B, C, etc. Roughly we put them into three groups.

Superior proteins—those of milk, egg, glandular and muscle meats, the animal group.

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10. Garland, Joseph: Boston M. & S. J. **192**:581 (March 26) 1925.

11. Van Nuys, Fresenius: Boston M. & S. J. **192**:1242 (June 25) 1925.

Inferior group—those of grains, nuts, legumes and tubers, the vegetable group.

Third group—gelatin, which is less valuable by itself than any of the others because it lacks the amino-acids, tyrosin and typotophan, both of which are essential to life.

When the arguments for and against the low protein diet are discussed there is one basic principle that both sides of the controversy must agree on, namely, that the main protein requirement is not so much the quantity as the quality of the protein. A flesh abstainer may live for years in perfect health provided his vegetable proteins be supplemented by those of milk and eggs. Truly they are, as McCollum calls them "protective foods." According to McCollum, milk and milk alone determines the physique of a race regardless of climate, occupation or hygiene.

TUBERCULOSIS

Tuberculosis of Joints.—Ely [12] reports a rare opportunity for histologic study of a whole tuberculous joint. In a patient aged 28 with tuberculosis of the spine there was involvement of a finger joint, which was amputated. The complete examination of this resulted in the following observations:

1. Only two tissues were involved directly in the disease, the synovial membrane and the marrow in the immediate vicinity of the joint. In this specimen, the involvement was mostly synovial.

2. The synovial membrane was thickened, villous and thrown into folds. Tubercles had formed in its substance. The presence of areas of beginning coagulation as well as of distinct effort at encapsulation indicated that the case was one of medium severity, neither very slow and benign nor very rapid and destructive in its course.

3. There was no evidence of the precipitation of fibrin either on the surface of the cartilage or on the synovial membrane. The cartilage was slightly fibrillated on its surface. At its margin the diseased tissue tended to encroach on it, and to take its place, as it were.

4. In the bone where marrow involvement was present, the bone trabeculae had begun to disappear. They were thin and sparse. Just what the process was by which this had taken place was hard to determine, for there was no sign of the classic rarefying osteitis.

5. The tuberculous process in the bone marrow, together with that in the synovial membrane, communicated at the margin of the cartilage. There was no evidence of perforation of the cartilage. The cartilage to the naked eye inspection was almost normal, in spite of the extensive

12. Ely, L. W.: Arch. Surg. **10**:751 (March) 1925; abstr., J. A. M. A. **84**:1148 (April 11) 1925.

involvement of the synovial membrane; it was only a trifle roughened. In other words, the preponderant involvement of the synovial membrane indicated that the original tubercle was in it, and that the bone marrow became involved by extension under the margin of the articular cartilage.

6. The tuberculous granulations in the marrow were not discrete and regular, but were scattered and irregular in distribution, showing a marked tendency to hug the under surface of the articular cartilage. This is the usual state of affairs, indicating the futility of the proposed operation of removing the disease at an early or a late stage. It is, of course, impossible to say how far the granulations have spread in the marrow at any stage. One can never be positive that the marrow is not involved in the operation of synovectomy.

[ED. NOTE.—This careful study of Ely's seems to us of great value. He is a close and trained clinical and laboratory observer. We need much added knowledge both as to localization of the initial joint lesions of tuberculosis and as to the sequence of the subsequent joint tissue involvements. It does not seem to us that Ely has proved that even in the reported case the primary involvement was in the synovial membrane. We should welcome such proof but thus far it seems to be lacking in all careful microscopic studies.

In order that such knowledge may be obtained and clinical observations made of true value we need most of all laboratory evidence that the lesions whose clinical course we may be studying are, or are not, due to tuberculosis. The present so-called clinical evidence, in our experience, has often been untrustworthy and has led to wrong conclusions and to unwarranted and sometimes vicious treatment. We should seek guinea-pig evidence whenever it is possible to obtain fluid by aspiration. We believe that nonmutilating and meticuously aseptic biopsies are indicated in that large class of cases in which a reasonable doubt exists as to the causative agent of the lesion.]

Treatment of Open Tuberculous Joints in Closed Casts.—Capecchi [13] recommends very highly the method of Solieri which consists in treating open tuberculous joints in closed casts. He is convinced that nothing is worse for those joints with discharging sinuses than motion and much handling. He has been surprised to see them heal in a comparatively short time in closed casts. The pus running from the sinuses macerates the skin underneath the plaster, but this imprisoned discharge, which generally induces the surgeon to change the cast, is considered by Capecchi to be the chief factor in healing. He believes that a kind of autovaccination takes place, the skin in the neighborhood

13. Capecchi, Egisto: Ztschr. f. orthop. Chir. **46**:525, 1925.

of the sinus selecting and filtering the vaccinating contents of the pus. He recalls the work of Petruschky, Ponndorf and Maragliano, who use tuberculin and similar agents for vaccination of the skin.

[ED. NOTE.—We hope that some other more attractive even if more laborious method for treating these lesions may be found.]

End-Results of Extra-Articular Operation of the Tuberculous Shoulder.—Two years ago Baron published a new method of extra-articular arthrodesis of the tuberculous shoulder joint consisting in temporary resection of the head of the humerus and the placing of the end of the diaphysis on the lateral border of the scapula. Schulhof [14] has compiled a number of cases in which successful operations were done after this method and states that a complete fixation is attained without touching the tuberculous tissue. The pain is relieved; the healing makes rapid progress, and the functional result is very satisfactory, much better than under the ordinary conservative treatment.

ARTHRITIS

Rheumatism: The Harrington Lecture.—McCallum [15] notes that great confusion has prevailed in the use of the term rheumatism since it has been applied to all sorts of painful affections of the joints and even to more indefinite muscular pains. Deforming types of arthritis have been included, and such expressions as rheumatoid arthritis have been employed. But for many years it has been recognized that there is one condition in which painful swelling of the joints is variously combined with tonsillitis, chorea, fever, subcutaneous nodules, and especially with profound disease of the heart; this stands apart from all the rest and is commonly known as acute rheumatic fever.

Rheumatism is an infectious disease that occurs in children or in young adults, sometimes with an acute course, more often progressing slowly with several explosions of acute illness in which different symptoms may become especially prominent. It may subside and leave the patient in a state of apparent well being, but it usually produces permanent changes in the heart. Other affections that might possibly be confused with rheumatism are numerous. Thus, arthritis with painful swelling of the joints is a feature of many infectious diseases.

From all these diseases rheumatism stands out sharply distinct. If attention is centered on the joint affection it is soon realized that, although excessively painful, the changes in the joint in rheumatism differ from all the others in affecting especially the periarticular tissues and in not being destructive.

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14. Schulhof, E.: Zentralbl. f. Chir. **52**:1470 (July 4) 1925.
15. McCallum, W. G.: J. A. M. A. **84**:1545 (May 23) 1925.

He discusses the various features of the disease, the pathology of the heart, the joint and other tissues. As to the cause of the disease, little can be said. It seems certain that rheumatism is caused by a specific infectious agent of some peculiar kind, not recognizable by our present methods of study and not as yet found to be transferable to laboratory animals. The constancy and peculiarity of the characteristic lesion makes it seem improbable that any of the numerous forms of bacteria that have been isolated in such cases have a true etiologic relation to the disease.

Rheumatic Infection in Childhood: The Subcutaneous Fibroid Nodule as an Early Manifestation.—After examining 100 consecutive children for subcutaneous nodules irrespective of the complaints for which they were brought to the clinic of the Royal United Hospital, Coates [16] contends that such nodules are a definite physical sign that can be elicited in a large number of children who present themselves as outpatients suffering from subjective symptoms suggesting rheumatic infection prior to clinically demonstrable cardiac lesions.

Typhoid Arthritis of the Hip.—Caussade and Tardieu [17] report three cases of typhoid arthritis of the hip in adults. These lesions developed as complications in cases of severe typhoid fever, appearing from the twenty-ninth to the thirty-fifth days. The hip symptoms were slow to localize and at first the complaint was of vague pain in the region of the pelvis. Joint destruction proceeded rapidly and ended in partial or complete ankylosis. Roentgenologically there was both destruction and proliferation so that the appearance was like an ostearthritis. Surgical intervention was not necessary and the plan of fixation in plaster was followed. The temperature slowly subsided and the symptoms disappeared but serious functional disability remained in the affected hip.

NEOPLASMS

Codman [18] graphically explains the nomenclature recommended by the committee of the Clinical Pathological Association which has been accepted by the division on bone sarcoma of the American College of Surgeons. His excellent roentgenograms, together with histologic illustrations and clinical descriptions, clearly differentiate the different types of tumor. The lines are definitely drawn and there should be little opportunity for confusion in nomenclature if they are carefully studied.

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16. Coates, Vincent: Brit. M. J. **1**:550 (March 21) 1925.

17. Caussade, G., and Tardieu, A.: Bull et mém. Soc. méd. d. hôp. de Paris **49**:329 (March 6) 1925.

18. Codman, E. A.: Am. J. Roentgenol. & Radium Therap., February, 1923, p. 105.

[ED. NOTE.—We feel that Codman's patient, accurate work should be rewarded by a general agreement on the part of surgeons who are faced with the difficulties of diagnosis of bone tumors to follow the path he has marked. After much confusion it is surely gratifying to discover a means to the lessening of our difficulties. We feel that surgical practice owes an increasing debt to Amory Codman.]

Bone Tumors.—Brooks [19] has had eighty-three cases of bone tumor, of which sixty-one were benign and fifteen were malignant sarcoma and have had fatal metastases in all but one instance (less than two years after operation). The remaining seven cases he reports because five of the patients are still alive and apparently cured for three or more years. These, however, did not show the characteristics of malignant growth. He offers the following conclusions and it is especially to be noted that he feels that there is no harm in doing a biopsy on a benign tumor and that it does not alter the ultimate prognosis in a malignant sarcoma.

1. For practical purposes all sarcomas of bone may be divided into two groups. In one, the tumor forms metastases, and in the other, no distant mestastases occur.

2. There is at the present time no hope of cure in the first group, while all cases of the second group are cured by any means which result in a local removal of the tumor tissue.

3. The clinical differentiation of these two groups is difficult and often impossible.

4. Bone tumors may be as effectively cured by complete local excision as by radical amputations.

5. Exploratory incision for diagnosis or local operative removal does not influence the ultimate prognosis of the disease.

6. Every means available, including exploratory incision and removal of tissues for microscopic diagnosis, should be instituted to determine if the bone tumor is of the metastasizing or nonmetastasizing variety.

7. In a given case, therefore, of sarcoma of bone, local excision or amputation is to be chosen according to which gives the best immediate functional result.

Cartilage Containing Tumors.—Keiller [20] presents a group of cases with cartilage containing tumors of bone origin. The study is confined strictly to those tumors in which the intercellular substance is chondral, or chondral and myxomatous. The idea is that chondrin

19. Brooks, Barney: Southern M. J. **18**:274 (April) 1925.

20. Keiller, V. H.: Surg., Gynec. & Obst. **40**:510 (April) 1925.

and mucin are essentially the same, each representing a slightly different phase in the activities of identical cells. The paper does not deal with the cartilaginous tumors that contain bone; this is a separate problem. The material is described with a view to determining, if possible, wherein the benign-malignant gradient of this group, clinical and histologic, should be placed. Eight cases are reviewed with clinical aspects, a careful histologic and gross analysis, and a fair end-result period is given.

Lipoma of Tendon Sheath.—Filho [21] reports a case of arborescent lipoma of the tendon sheaths. He considers it distinct from the arborescent lipoma of joints which is due to tuberculosis. Lipoma of the tendon sheath is not tuberculous so far as can be determined by histologic study and by animal inoculation. A study of the literature indicates the condition to be rare.

[ED. NOTE.—Lipoma arborescens is not usually due to tuberculosis of the joints. Reference should be made to Painter's studies.[22]]

COXA PLANA AND BONE AND JOINT DISEASE OF UNCERTAIN ORIGIN

Etiology of Coxa Plana.—Delitala,[23] in discussing the etiology of coxa plana, says that there seem to be two types: one in which, with very little doubt, there is an infectious factor, and another in which it is difficult to be sure of an infectious factor. In the latter he feels that a congenital factor plays a large part. Among the reasons for believing in a congenital factor are the frequency of the lesion being bilateral, the frequency of its being a familial type of deformity, and the presence of other congenital lesions. His conclusions are: Coxa plana is a modification of the form of the femoral head due to developmental alteration of the cephalic nucleus in the progress of its calcification and also of the connecting cartilage; the cephalic nucleus still remaining partly cartilaginous yields and becomes deformed under the action of the body weight. The disturbances of ossification have in a majority of cases a congenital origin. During the period of intrauterine life, through causes as yet only partly known to us, there are disturbances in the bony tissues or the organs which regulate ossification, and in consequence deformities occur of which coxa plana is the most characteristic. The same causes probably give rise to congenital alterations in form, as in congenital dislocation. But one cannot admit that congenital dislocation and coxa plana are the same thing. In one there is an alteration of form, while in the other there is an alteration in

21. Filho, Brandao: Chir. d. org. di movimento, **9**:235 (March) 1925.

22. Painter, C. F., and Erving, W. G.: Boston. M. & S. J., March 19, 1903; abstr., J. A. M. A. (April 4) 1904.

23. Delitala, F.: Chir. d. org. di movimento **9**:309 (March) 1925.

the structure of the bony tissue itself. The roentgenogram presented serves to confirm him in the opinion that in the same individual multiple congenital alterations, both of the nuclei in the process of ossification and in the connecting cartilages, may occur. There are recorded in the literature numerous cases of coxa plana in which the infectious nature does not appear doubtful. In many of these cases there is an atypical condition. The author believes that the cases of congenital coxa plana with typical characteristics can be clearly distinguished from the forms due to an infective cause, forms that are sometimes described as being the results of osteomyelitis of the hip and sometimes as due to coxa plana.

[ED. NOTE.—We are not in sympathy with Delitala in these observations. Hypothetic reasoning will do little to lessen the obscurity that surrounds such conditions as coxa plana. We do not believe in two types of this disease. As described by Legg it represents a clear-cut clinical entity. If it is of infectious origin, then all of Delitala's observations on growth disturbances become worthless. If the cause is associated with the progress of ossification, then infection is not a causative factor. An infectious epiphysitis may cause an appearance in the roentgenogram similar to coxa plana.]

Camurati [24] reports very interesting observations on three cases of coxa plana followed for periods of eleven, twelve and thirteen years. The early roentgenograms show the characteristic appearances including the fragmentation of the nucleus. The late ones show a short femoral neck covered by the femoral epiphysis, which is ovoid and flattened with its superior margin at a line below the top of the great trochanter.

Adolescent Coxa Vara.—Kidner [25] reports six cases of adolescent coxa vara and comes to the conclusion that this condition is a distinct entity consisting of a disturbance of the nutrition of the epiphyseal line. It results in various degrees of coxa vara. This deformity is due to weight bearing in heavy children, which causes a displacement of the head through the giving way of the poorly functioning epiphyseal line at the upper end of the femur. He favors early application of a plaster spica in abduction and internal rotation; such treatment if of sufficient duration will bring about "complete anatomic restoration and perfect function." P. D. Wilson, in discussing this paper, emphasizes the negative findings as regard metabolism and blood chemistry in these cases. The mechanics of the hip joint probably is an important etiologic factor. Wilson also favors open correction in these cases in which complete anatomic restoration is not brought about by manipulation.

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24. Camurati, Mario: Chir. d. org. di movimento **9**:213 (March) 1925.
25. Kidner, F. C.: J. Bone & Joint Surg. **7**:241 (April) 1925.

[Ed. Note.—We do not agree that the functional results following manipulation are, as stated by Kidner, "perfect." For this reason we have found treatment by open reduction necessary in most cases, especially in those not seen immediately after the displacement of the epiphysis.]

Osgood-Schlatter Disease.—Grossman [26] reports five cases of the Osgood-Schlatter disease, which is not an uncommon condition and is generally easily recognized in the roentgenogram. His summary is concise and well sums up all the important points.

1. Osgood-Schlatter's disease is also known as starting of the epiphysis, acute epiphysitis, periotitis, tuberositis tibiae and apophysitis tibiae.

2. It occurs in children between the ages of 10 and 15 years. It is more common in boys than in girls.

3. In children under 10 years of age there is no separate center of ossification. The center appears earlier in girls than in boys. It may appear earlier or be farther developed in one tibia than in the other. The separate center for the tubercle begins to unite about the fifteenth year, usually earlier in girls than in boys, and is generally firm by the eighteenth year.

4. Trauma plays an important rôle in the etiology. Symptoms or signs of late rickets were not present in any of the cases of this series.

5. Simple strapping is all that is required in treatment.

6. The prognosis is good as to end-result, but the enlargement of the tibial tubercle may persist.

7. The condition is in many respects analogous to the similar condition in the hip often called Perthes' disease (Legg-Calvé disease). Especially is this true of the roentgenographic appearance of the epiphysis in the two conditions. Both conditions occur in adolescence; the symptoms are moderate pain and tenderness and only partial loss of function. They are both self-limited diseases and the patients usually recover without causing any serious or permanent damage to the parts affected. Köhler's disease or isolated disease of the tarsal scaphoid pursues a similar course.

[Ed. Note.—The notes made by Grossman on Osgood-Schlatter disease are given place here not because they of themselves represent progress but because they indicate the progress of an idea. It has recently become the fashion to observe the similarity that exists between these various clinical diseases.]

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26. Grossman, Jacob: M. J. & Rec. **121**:534 (May 6) 1925.

Freiberg-Koehler's Disease.—Koehler [27] points out that the typical affection of the second metatarsal head usually called after him was described before his first publication by Freiberg (Cincinnati), who considered it a common fracture in a weak foot caused by traumatism. Freiberg has not described the extensive thickening of the distal half of the affected bone, a change that Koehler thinks the most characteristic and the most important feature of the pathologic picture. Koehler proposes the name "Freiberg-Koehler's" disease.

Madelung's Deformity.—Merlini [28] discusses the literature of Madelung's deformity and reports two cases. The true deformity is not due to trauma and forms a part of the group of skeletal affections of adolescence. It rarely occurs in adult life and rarely in childhood. It occurs more commonly in the female in the proportion of two out of three cases. It is much more often bilateral than unilateral. The deformity consists of a double curve of a radius with the concavity toward the flexor surface and toward the ulnar side of the forearm with a concomitant displacement posteriorly of the lower end of the ulna. With the two curves of the radius there also is a torsion of the long axis in the direction of pronation. Many believe the deformity to be due to late rickets. The author's conclusions are:

1. It is useful to distinguish traumatic or false cases from true or spontaneous cases, and thus make two distinct classes.

2. Referring to the true cases, he holds with the majority of authors that the deformity is an occupational disease occurring as a rule in adolescence and due to joint strain from repeated movements of dorsal flexion of the hand on a skeleton that is predisposed.

3. The deformity consists essentially of a double curve of the radius, concave toward the volar and the ulnar aspects, limited to the lower third or extending more or less into the diaphysis, and due to the partial and unequal osteogenetic activity of the lower epiphyseal cartilage of the radius.

4. The valgus position of the elbow is due to the deformity of the radius and is produced by unequal pressure on the lower epiphyseal cartilage of the humerus.

5. The skeletal predisposition is due to a localization of the so-called late rickets, a very complex osseous dystrophy of obscure etiology but probably to be considered of an infectious nature.

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27. Koehler, Alban: München. med. Wchnschr. **71**, No. 4, 1924.

28. Merlini, A.: Chir. d. org. di movimento **9**:245 (March) 1925.

Dorsal Kyphosis in Growing Children.—Mathieu, Massart and Ducroquet [29] report eight cases with long dorsal kyphosis without angulation. Pain is present in the region of the vertebrae which may be aggravated by pressure on the spine, accompanied by rigidity. In the patients from 12 to 15 years old who have grown rapidly there is a kyphosis unless the patient is treated, and their roentgenograms are significant. There is a flattening of the vertebrae anteriorly, as seen in the lateral views, to a slight degree allowing the vertebrae above and below to overlap about 1 cm. In seven cases the lower dorsal vertebrae were affected. In one case all the vertebrae were flattened. Toward the intervertebral disks the profile of the affected bodies is somewhat irregular, giving the appearance of the intervertebral disks being pinched together between the vertebrae; this resembles a condition sometimes found in Pott's disease. The disk seems to keep its thickness but adapts itself to the irregularity of the vertebrae. There is no extensive erosion such as in Pott's disease. Mathieu points out the fact that some of these cases of painful kyphosis had been diagnosed Pott's disease. The roentgenogram shows the curious osteogenic lesion of development in the body of the vertebrae. It does not seem to be in any way related to syphilis or tuberculosis.

Osteochondritis Ischiopubica.—Valtancoli [30] reports a case of what he calls osteochondritis ischiopubica. The condition occurred in a child of 9 years and consisted of an enlargement of the bony and cartilaginous structures at the junction of the ischial and the pubic rami with lessened density. The symptoms suggested a beginning coxitis but the roentgenograms showed changes as noted. The tuberculin and Wassermann reactions were negative. Two similar cases have been reported by Van Neck under the name of pubic osteochondritis. Valtancoli suggests that the condition is analogous to Köhler's disease of the scaphoid and to Osgood-Schlatter's disease.

BONE AND JOINT SURGERY

Spasmodic Torticollis.—Finney and Hughson [31] report the last results of operation for spasmodic torticollis in thirty-two cases. They review the history of the operative treatment since 1641 when Minnius, a German army surgeon, first resected a portion of the sternomastoid muscle, and certainly the results in the reported cases justify the pessimistic prognosis given by Starr. No factor of general etiologic

29. Mathieu, Paul; Massart, and Ducroquet: Bull. et mém. Soc. nat. de Chir. **51**:220 (Feb. 28) 1925.

30. Valtancoli, Giovanni: Chir. d. org. di movimento **9**:281 (March) 1925.

31. Finney, J. M. T., and Hughson, W.: Ann. Surg. **81**:255 (Jan.) 1925.

importance was found in the author's cases although examples of almost all of the generally assigned causes were observed. The failure of most of the surgical procedures which have been employed has led them to try a radical type of nerve root excision which has already been described in a former Report of Progress in Orthopedic Surgery. The trunks of the upper three cervical roots are divided, usually on both sides, since in the majority of cases both sides are involved sooner or later. In the series of thirty-two operated cases, one patient has not been heard from recently. Of the remaining thirty-one patients three are unimproved, sixteen have been improved but not entiredly relieved, while twelve have been completely cured. The authors call attention to the fact that these operations cover a period of more than twenty years, that the earlier operations were incomplete and that the technic has been improved continually. The perfected operation has been used in only a few cases; too few and too recent to permit final judgment as to its merits, but at the same time in a sufficient number, they believe, to justify its more extended use.

[ED. NOTE.—We wish to emphasize the fact that this operation is difficult and that it should not be undertaken by any but an experienced surgeon who has thoroughly familiarized himself with the anatomy of the region.]

Rupture of Muscles and Tendons.—Gilcreest [32] states that the order of frequency of rupture of muscles and tendons in Achilles tendon, extensor quadriceps, biceps and triceps of the arm, rectus abdominis, supraspinatus and adductors of the thigh, trapezius, pectorals major and minor.

Senility, disease and excessive fatigue are etiologic factors in the rupture of muscles. The break always takes place when the muscle is in strong contraction and a group of antagonistic muscles is brought into action. It evidently occurs when there is a lack of coordination of muscular action and when a sudden, unexpected movement or muscular adjustment takes place. Often a distinct snap is heard.

Suspicion of a ruptured muscle or tendon should immediately be aroused when a person complains of having felt a sharp pain during a forceful muscular act, when a tumor is found over the muscle, and when the limb is decidedly weaker than the other.

In the treatment of tears, both rest and movement are healing factors, each in its place. Active exercise is the best form of massage. For rupture of a muscle operative repair is indicated. In case of doubt as to the exact diagnosis exploratory operation under local

32. Gilcreest, E. L.: Rupture of Muscles and Tendons, Particularly Subcutaneous Rupture of Biceps Flexor Cubiti, J. A. M. A. **84**:1819 (June 13) 1925.

anesthesia can do no harm and may prevent later embarrassment to the attending surgeon.

Lengthening of Quadriceps Tendon for Stiff Knee.—McChesney [33] reports excellent results in five cases from the operation for lengthening the quadriceps tendon first described by Bennett in 1919. He considers that the procedure is indicated in stiffness due to any of the three following general pathologic causes:

1. Adhesions of muscle to bone following sepsis, usually an osteomyelitis, mild or severe, complicating fracture.

2. Adhesions of muscle to bone or to muscle following operation but with no sepsis.

3. Resistant contracture of the quadriceps with no adhesions, due to prolonged fixation as for joint disease.

The author states that the operation has little risk and no especial difficulties. He believes that it should be better known and more widely used.

Joint Mice in the Elbow.—Pigeon, Bernard and Johnson,[34] army surgeons in Algiers, report six cases of joint mice in the elbow of traumatic origin. In four cases the loose bodies were removed by operation and these patients recovered uneventfully. In the other two operation was not done, but the condition appeared similar. Clinically, after the acute pain at the onset of the injury had subsided, there was little pain, and the patients came to the hospital more because of impaired motion and stiffness than for any other reason. In three cases a posterior incision was used, while in the other an epicondylar incision was sufficient.

Arthroscope in the Diagnosis of Injury to the Semilunar Cartilages.—Kreuscher [35] reports a new procedure in the diagnosis of internal derangements of the knee. He employs an arthroscope consisting of an electric carrier with lens system and electric light which is introduced into the joint by means of a pointed cannula. The joint is previously distended with oxygen or nitrogen gas. By this means it is possible to inspect the semilunar cartilages at their various attachments and by manipulation of the arthroscope against the cartilage to demonstrate any undue mobility of the latter. He feels that derangements of the semilunar cartilages are much more common than supposed and that by the aid of this instrument the diagnosis can be made more surely than by other means.

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33. McChesney, G. H.: California & West. Med. **23**:732 (June) 1925.

34. Pigeon, Bernard and Jonathan: Bull et. mém. Soc. nat. de Chir. **51**:140 (Feb. 14) 1925.

35. Kreuscher, P. H.: Illinois M. J. **47**:290 (April) 1925.

[ED. NOTE.—The question that arises in our minds is whether it would not be better to make a small incision to obtain the same information by direct visual inspection rather than by using the arthroscope. In the majority of cases in which the diagnosis is obscure we believe that exploration is justified.]

Internal Derangements of the Knee.—Bristow [36] has contributed an extremely able review of the entire subject of internal derangements of the knee. The matter is discussed under the headings history, anatomy, physiology, mechanism of injury, types of injury, differential diagnosis, treatment and end-results. The article does not lend itself readily to summarizing but constitutes a valuable paper for study and reference.

Old Fracture of the Patella.—Pieri [37] reports a case of old fracture of the patella in which there was wide separation of the fragments and hypertrophy of each. He removed the proximal fragment subperiosteally and attached the quadriceps tendon to the distal fragment, using the periosteal covering of the proximal fragment in making the junction. Good function was obtained.

Operative Reduction for Congenital Luxation of the Patella.—Conn [38] reports a case of congenital luxation of the patella successfully reduced by a new operative procedure. The luxation was associated with a well marked genu valgum and this was first corrected by a series of wedging plaster casts. Operation was then performed and the tight external portion of the joint capsule which prevented reduction was freely divided through a lateral incision. It was also necessary to free the vastus externus from its attachment to the quadriceps tendon. The patella could then be replaced. The mesial portion of the joint capsule was now very loose and from this an elliptical piece with the synovial membrane attached was excised, and the edges of the defect approximated and sutured. A large defect remained in the capsule on the outer side where the edges of the incision were widely separated. Into this defect was transplanted the free flap from the mesial side, and it was of sufficient size completely to close it. An excellent functional and anatomic result was obtained. The author attributes much of the success to the preliminary correction of the knock-knee. A very complete bibliography is appended to the article.

Excision and Replacement of the Astragalus Following Dislocation.—Sneed [39] reports a case of complete lateral dislocation of the astra-

36. Bristow, W. R.: J. Bone & Joint Surg. **1**:413 (April) 1925.
37. Pieri, G.: Chir. d. org. di movimento **9**:288 (March) 1925.
38. Conn, H. R.: J. Bone & Joint Surg. **7**:370 (April) 1925.
39. Sneed, W. L.: J. Bone & Joint Surg. **7**:384 (April) 1925.

galus with fracture of the external malleolus. Operative reduction was required and it was first necessary completely to remove the astragalus before replacing it in normal relation. In spite of the fact that the bone was deprived of all blood supply it has survived and has not altered materially in its appearance during the five years that have elapsed since injury. The patient walks without limp. There is only slight limitation of flexion and extension, but there is marked limitation of inversion and eversion. The author has made a detailed study of the blood supply of the astragalus and has come to the conclusion that there is no main nutrient artery, and, further, that in all severe dislocations of the astragalus the blood supply of the bone is interrupted, perhaps temporarily destroyed.

(To be continued)

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TRANSACTIONS OF THE AMERICAN ASSOCIATION FOR THORACIC SURGERY

EIGHTH ANNUAL MEETING, WASHINGTON, D.C.
MAY 4, 5 AND 6, 1925

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WHAT MAY WE EXPECT TODAY FROM THORACIC SURGERY?*

NATHAN W. GREEN, M.D.
NEW YORK

This society interested in the unfamiliar problems of the chest convenes in eighth annual meeting for the second time in our capital city. This time we take our place in the family circle of the Congress of American Physicians and Surgeons but as one of the younger members. Our youth is still upon us but our older and sagacious friends have given us encouragement at every turn and are accompanying us into a sturdy adolescence. Many of our members are members of the older groups. We value highly the encouragement of their presence.

It is in the early days of existence that we must have skilled and steady hands to guide us. As we walk more firmly the body of the society will go on and the presiding officer will be borne along as one among his friends, accompanying them rather than presiding over them. I thank you for the expression of your friendship in placing me in this office: I also appreciate the responsibility you have imposed on me.

The members of the profession have awakened to renewed interest in intrathoracic surgery. Few new procedures have been instituted in the span of our existence, but old ones have been taken up, scrutinized and evaluated and there is today a trend toward standardization. Originators are at work also and those who perfect what others have conceived. To all belongs credit for our present status. Cooperation between internist and surgeon is proving of more and more value and happily becoming current.

We are fortunate in having with us so many of the pioneers of this branch in our country: Meyer, the founder of this society; Lilienthal; Chevalier Jackson and others from afar—men whose names will have an enduring place in the history of progress. To those who have assembled I shall endeavor to present the subject in the most profitable way. Individual experience in certain subdivisions of this field is still confined to a few case histories. In other subdivisions individual experience has been large—all is valuable and will in time become more so. Some have unusual opportunities to study many similar cases and with the added advantage of teamwork with well known associates. From these it is justly our expectation to have valuable results and to them we must look for indications. It is of a subtler quality of mind to know when and when not to operate than to know the technic

* Presidential address read in part.

of procedure. To those who have been specially blessed with this good judgment we shall like "hungry sheep look up," but contrary to Milton's "Lycidas" we feel confident we shall be fed.

This year the surgical treatment of pulmonary tuberculosis is coming to the fore. It has been featured in the literature, and at this meeting it is our hope to elicit discussion that will further place the resources of the general surgical hospital at the service of the needy tuberculous patient. In this perhaps lies one of the most fertile fields for thoracic surgery.

The cure of bronchiectasis, for more than twenty years of somber outlook but punctuated by the many brilliant successes of Sauerbruch, Lilienthal and others, has received a new ray of cheer from the cautery lobectomy of Graham and the graded thoracoplasty of Hedblom, formerly of the Mayo Clinic. This calls to recollection the words of Samuel Robinson, in his presidential address before this society in 1922, that it had always been his belief that the greatest triumph in thoracic surgery would be the surgical eradication of this deplorable disease. The forty-nine cases of lung suppuration reported by Meyer in 1924 furnish a splendid example of thoughtful procedure and careful handling. Two conservative procedures [1] are worthy of commendation: ligation of a branch of the pulmonary artery and the establishment of a permanent fistula for drainage and aeration.

In the single lung abscess, after more conservative measures have been thoroughly considered, a cure has been quite uniformly obtained by drainage established preferably by the two stage method.

The question of differential pressure or its omission no longer occupies the center of discussion. That was settled at our Chicago meeting. We must have it at hand even if only in the simple form of the oxygen tank and rubber face mask. Methods of anesthesia are improving. Ethylene gas is being used more frequently.

It is strange that more general use has not been made of the differential pressure chamber such as that of Sauerbruch and of Willy Meyer. The inertia to which even the trained human mind is subject and the destructive criticism of apparent failure of procedures, even though brilliantly conceived has undoubtedly held back many from making more signal progress in the domain of exploratory inspection in intrathoracic pathology.

We must establish relations of confidence between the public, as patients, and their medical advisors; it therefore behooves us to move with circumspection.

---

1. Meyer, Willy: Lung Suppuration and Its Treatment, Arch. Surg. **6**:423 (Jan.) 1923.

It is less than five decades since the modern surgical treatment of abdominal pathology was instituted. The knowledge thus gained has been disseminated through all ranks of the profession but there are still some members of the medical brotherhood who do not recognize or will not accept the benefits of incisive surgical procedure for their trusting patients.

Our Association for Thoracic Surgery is composed of a representative group of widely differentiated specialists all interested in the chest and in the common cause of curing disease inherent in the contained viscera. We will make better progress in organization of service. Our present rotating intern service is subversive of technical advance. Much might be done by hospital authorities to encourage better operative efficiency.

With the increase of success due to improved operating and earlier and more accurate diagnosis, the knowledge of surgical intervention in the chest should be spread abroad more rapidly than was the case in abdominal surgery.

In presenting a review to this society I have gone over the literature appearing in the last year and a half and have endeavored to select a comprehensive list of records. It is my hope that references given here may prove of service to all who may consult them further.

CHEST WALL

Malignant tumors of the chest wall have been removed with freedom from clinical symptoms lasting from one to four years.[2] A deep form of subpectoral phlegmon arising from small digital inflammations without involvement of the ulnar glands and frequently rupturing into the pleural cavity has been described.[3] Skin sliding operations for obliteration of large cavities and the open method of treating malignant tumors of the chest wall invading the thoracic cavity, practically transforming deep seated tumors into superficial ones preparatory to radiotherapy, have been noted.[4]

The repair hernia of the lung has been reported[5] and a "cold abscess" of the costal border caused by the aspergillus fumigatus has been identified.[6]

---

2. Heuer, G. J.: Ann. Surg. **79**:670 (May) 1924.

3. Hoefer, B.: Arch. f. klin. Chir. **131**:502, 1924.

4. Beck, E. G.: Open Method of Intrathoracic Surgery, Arch. Surg. **8**:327 (Jan.) 1924.

5. Satta, F.: Arch. ital. di chir. **9**:509, 1924.

6. Bolognesi, G., and Chiurco, A. G.: Atti d. r. Accad. d. fisiocrit di Siena, 1924, No. 1, p. 35.

EMPYEMA

When the society was founded it was a debated question whether in thoracic surgery should be included the question of empyema—acute or chronic. After some discussion it was finally decided to include it as one of the subdivisions in the surgery of the chest. And then what happened? Like the camel in the fable it almost threatened to occupy the whole tent, driving out the more rightful claimants to true thoracic surgery.

Much has been written, much good has been done, and many lives have been saved by the intelligent scrutinizing of the various procedures and fitting them to the different types of infection, but aside from certain technical modifications in the operation there has been little change in the treatment of acute or chronic empyema. The acute streptococcal type is now acknowledged to be best treated in a conservative way by aspiration or air tight drainage until the acute storm is past —followed later by a wider drainage of the cavity when the septicemia has subsided.

Bettman,[7] Nather and Ochsner,[8] Romanis,[9] Vincent,[10] Suermondt,[11] Schmerz [12] and Major [13] have all recently furnished contributions to the literature of this subject. Hamet [14] has compiled the material of the Brest influenza epidemic and on the basis of his experience has reached the conclusion that in one half of the fatal influenza cases a purulent streptococcus pleurisy was present as the presumable cause of death. Ameline and Lubin [15] have offered an intermuscular incision with rib resection. Rosenthal [16] has advocated what he terms "oleothorax," the injection of a considerable quantity, from 200 to 1,000 c.c., of oil into the pleural cavity. We mention this without comment.

In the chronic form Murstad [17] reports from the Christiania Riks Hospital the treatment of twenty-eight chronic nontuberculous and twelve tuberculous empyemas. He recommends for the tuberculous cases puncture preceding extrapleural thoracoplasty in two stages, with

7. Bettman, R. B.: Illinois M. J. **45**:127 (Feb.) 1924; Treatment of Empyema, J. A. M. A. **82**:359 (Feb. 2) 1924.
8. Nather, K., and Ochsner, A.: Surg., Gynec. & Obst. **39**:94 (July) 1924; Deutsch. Ztschr. f. Chir. **188**:101, 1924.
9. Romanis, W. H. C.: Practitioner **113**:331 (Nov.) 1924.
10. Vincent, H.: LaClinique **19**:213, 1924.
11. Suermondt, W. F.: Deutsch. Ztschr. f. Chir. **186**:1, 1924.
12. Schmerz, H.: Arch. f. klin. Chir. **131**:361, 1924.
13. Major, R. H.: M. Clin. N. A. **7**:1051 (Jan.) 1924.
14. Hamet: Arch. de med. et pharm. nav. **114**:81, 1924.
15. Ameline and Lubin, P.: Paris méd. **1**:93 (Jan. 26) 1924.
16. Rosenthal, G.: Clinique **19**:174, 1924.
17. Murstad, E.: Norsk Mag. f. Laegevidensk. **85**:185 (March) 1924.

puncture between the stages and following the second stage as long as any fluid remains in the empyema cavity.

Nather [18] also contributes an article on the methods of treatment of total empyemas, dividing them into three groups. Bettman [19] makes the very significant statement that a closed, unobliterated cavity even though sterile will probably become reinfected and lead to a recurrence.

TUBERCULOSIS OF THE LUNGS

During the last year and the spring of 1925 renewed interest has been manifested in the surgical treatment of pulmonary tuberculosis. In this field lies the possibility of great service to the community and of great economic saving to modern civilization. Our confrères abroad have outstripped us in the efforts in this field so far. Friedrich, who did his first extrapleural thoracoplasty not twenty years ago, and after him Sauerbruch have given this matter great impetus on the Continent, but only comparatively lately in this country has there been concerted action to place this subject on a generally accepted basis. Owing to certain restricted legislation imposed on our general hospitals, because of an obsolescent fear of adult contagion in a well regulated surgical ward, progress in this line has been chiefly made by those having access to tuberculous sanatoriums or to wards especially devoted to the care of tuberculous patients. It is to be hoped that this ban may be lifted where it now exists so that in the near future the tuberculous patient may not be denied the surgical resources of which his more fortunate and more robust brother may avail himself—always under proper ward regulations.

At our last meeting a symposium on collapse therapy in pulmonary tuberculosis was held at the Mayo Clinic. At that time papers were read by Blanchet,[20] Singer [21] and Archibald [22] and among those taking part in the discussion were Willy Meyer, Butler, Eloesser, Wells and Freeman. Contributions to the literature on this subject during the last year and a half have been made by Archibald,[23] who advocates the two stage operation and reports thirty-nine posterior thoracoplasties with a low operative mortality; Alexander,[24] who reported that among

18. Nather, K.: Wien. klin. Wchnschr. **37**:305 (March 27) 1924.

19. Bettman, R. B.: Surg. Clin. N. A. **4**:821 (June) 1924.

20. Blanchet, S. F.: Treatment of Pulmonary Tuberculosis with the Help of Artificial Pneumothorax, Arch. Surg. **10**:306 (Jan.) 1925.

21. Singer, J. J.: Pneumothorax, Arch. Surg. **10**:312 (Jan.) 1925.

22. Archibald, Edward: A Contribution to the Subject of Extrapleural Thoracoplasty in the Treatment of Pulmonary Tuberculosis, Arch. Surg. **10**:328 (Jan.) 1925.

23. Archibald, Edward: Am. J. Surg. **38**:17 (Feb.) 1924.

24. Alexander, John: Am. J. M. Sc. **168**:1 (July); **168**:268-412 (Aug.) 1924.

1,024 cases of advanced tuberculosis from 1918 to 1923 he noted a mortality of 12 per cent. in the first month after the operation and 19 per cent. later on—26 per cent. of the cases were improved and 32 per cent. were cured; and by P. K. Brown,[25] who says, "The most signal recent contribution to the therapy of tuberculosis has been the improvement in methods of bringing about rest of the actively diseased area; for it is rest alone that has stood the test of time in the treatment of the disease. Of the surgical means of producing rest, artificial pneumothorax has the widest application and it is unquestionably the greatest modern achievement." He further states that resection of the phrenic nerve on the more advanced active side is probably justifiable in selected cases, but cannot be of any very great assistance. In case artificial pneumothorax should fail for any reason, a thoracoplasty is certainly in order on the same grounds that justified the attempt at pneumothorax.

W. L. Brown [26] says thoracoplasties are the operations that seem to be accomplishing the most in pulmonary tuberculosis. Bull [27] maintains in regard to extrapleural thoracoplasty, in reporting ninety-two cases, that as one can rely on saving one third of the patients who without the operation would be doomed no practitioner has now the right to withhold the chance of operation from suitable patients. In nine and one half years, between May 1, 1914, and Nov. 1, 1923, he performed ninety-two extrapleural thoracoplasties for pulmonary tuberculosis. The operation was performed fifty-six times on the left side with 35 per cent. mortality; on the right side thirty-six times with 19.4 per cent. mortality; 48 per cent. were free from symtoms for more than one year.

Davies [28] calls attention to the brilliant results of surgical treatment in the form of complete pneumothorax and thoracoplasty. Denk [29] states that the best results at the First Surgical Clinic in Vienna were obtained with Sauerbruch's paravertebral thoracoplasty performed in fifty-five cases. When a good result was not obtained by means of Sauerbruch's thoracoplasty, it might still be obtained by phrenicotomy. It was performed by Denk as a test operation before thoracoplasty. No radical operation should be done in case the condition became aggravated after phrenicotomy on the less affected side.

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25. Brown, P. K.: Am. Rev. Tuberc. **8**:484 (Jan.) 1924.

26. Brown, W. L.: Southwestern Med. **8**:275 (June) 1924.

27. Bull, P.: Proc. Roy. Soc. Med. (Sect. Med. & Surg.) **17**:1-48 (March) 1924.

28. Davies, H. M.: Lancet **1**:1051 (May 24) 1924.

29. Denk, W.: Wien. klin. Wchnschr. **38**:19 (Jan. 1) 1925.

Eloesser and P. K. Brown,[30] in summing up their opinions on this procedure, state that: 1. Cavities that persist after pneumothorax because of unyielding strands or adhesions may be collapsed by the intrapleural severing of these adhesions. The value of this intrapleural pneumolysis is not yet established. 2. When pneumothorax is indicated but not possible the lung may be collapsed by thoracoplasty. 3. Paralysis of the diaphragm by extraction of the phrenic nerve may be practiced: (*a*) to set the affected lung partially at rest; (*b*) to determine the strain put on the sound lung by partial inactivity of the affected side (as a test for future thoracoplasty) and (*c*) to complete the effect of an artificial pneumothorax when the lung is distended and kept mobile by diaphragmatic adhesions. These three procedures seem to be advocated by several writers and appear to be in a fair way of becoming standardized practice.

Fraser,[31] considering the seriousness of thoracoplasty, says that the average results are "wonderfully good." Gondolfo [32] recommends that it be done in two or three stages. Law [33] maintains that it is indicated only in cases of long standing in which collapse of the lung (pneumothorax) has been unsuccessful. The dangers of the operation are decidedly lessened by performing the operation in two stages. He says that the results are satisfactory in the great majority of cases, and that the operation causes only slight deformity.

Lilienthal [34] presents an article well worthy of greater space than can be given it in this paper. In it two points are particularly noteworthy: (1) Collapse therapy with phrenic nerve resection puts the lung at rest to a greater degree than is possible by any other known method; it is only to be applied when the other lung can function sufficiently to support life and when it is not affected by rapidly developing tuberculosis. (*b*) The surgeon must never lose sight of the fact that although his wound may heal and his immediate objective be reached, his patient still has tuberculosis and will long require medical and hygienic treatment.

Losio [35] says that the object of phrenicotomy, suggested by Sauerbruch, is complementary to artificial pneumothorax or thoracoplasty. It may be advantageously performed as a preliminary step to the latter. Amberson [36] says that it is estimated that 15 per cent. of all patients

30. Eloesser, Leo; and Brown, P. K.: Am. Rev. Tuberc. **8**:519 (Feb.) 1924.
31. Fraser, T.: Edinburgh M. J. **32**:89, 1925.
32. Gondolfo, C. F.: Bull. et mém. Soc. méd. d. hôp. de Paris **48**:1101, 1924.
33. Law, A. A.: Journal-Lancet **44**:365 (July 15) 1924.
34. Lilienthal, Howard: Am. J. Surg. **38**:1 (Jan.) 1924.
35. Losio, L.: Policlinico (sez. prat.) **32**:83 (Jan. 19) 1925; abstr., Internat. Survey Med. **9**:571, 1925.
36. Amberson, J. B., Jr.: New York M. J. & Rec. **121**:32 (Jan. 7) 1925.

with pulmonary tuberculosis should be treated with some form of collapse and immobilization therapy. Pearson [37] states that the decision as to the performance of thoracoplasty is more a matter of prognosis than of diagnosis:

> A nice estimate must be made as to the chances of life and restoration to health of the patient, firstly, on the supposition that the operation is not performed, and, secondly, on the supposition that it is. Then, by weighing the one estimate against the other, judgment may be given. Such estimates can better be based upon a study of the symptoms and general condition of the patient than upon the physical signs.

In the procedure of artificial pneumothorax, Lorenyani,[38] on the basis of his favorable experience covering fifty cases, recommends it in all cases including incipient ones, the only contraindication being a weakened heart muscle. Fine [39] advocates partial collapse and recommends that it be continued periodically every week over a few months at least.

Bernard [40] (Baron Valtis) presents his results in 201 personal cases that were followed up a sufficient time to show the results of treatment. In his cases cures were obtained in 20 per cent.; 35 per cent. were improved. It is with pleasure that one reads his note on the economic benefits of this procedure:

> Two of the most conspicuous social benefits of pneumothorax therapy are the fact that the patients classified as cured or improved nearly all resumed their usual occupations (sometimes very quickly), and were rendered at the same time noncontagious: and that several pregnant women were able to carry their progeny successfully to term, while others treated outside of pregnancy were able later to bear healthy children.

Scharl [41] states that by means of artificial pneumothorax those processes can be successfully treated in which the fibrous component predominates, whereas the purely caseous process cannot be essentially modified by this procedure. Hervé [42] mentions the treatment of pleural adhesions in artificial pneumothorax by means of high frequency currents either by sparking or by electrocoagulation. He reports ten patients successfully treated by means of this procedure.

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37. Pearson, D. V.: Tubercle **5**:376 (May) 1924.
38. Lorenyani, G.: Gior. di clin. med. **5**:641, 1924.
39. Fine, M. J.: Am. Rev. Tuberc. **10**:630 (Jan.) 1925.
40. Bernard, L.; Baron, and Valtis: Bull Acad. de méd. **93**:46 (Jan. 6) 1925.
41. Scharl, P.: Cevosi Hetilap **68**:491, 1924; Zentralorgan f. d. ges. Chir. in ihre Grenzgeb. **30**:393, 1925.
42. Hervé, R.: Paris méd. **1**:547 (June 14) 1924.

LUNG SUPPURATION

In the surgical treatment of bronchial dilatation cautery lobectomy and graded thoracoplasty have been instituted and represent conservative advance. Guibal,[43] after describing the various operative methods, considers resection of the affected lung to be by far the most important, especially in disease of the lower lobe. In this opinion Lilienthal coincides.

Fronticelli[44] advocates intratracheal instillations of a certain oil (gomenol) with or without iodoform in certain cases of fetid bronchitis and pulmonary gangrene.

Archibald[45] reports a method of lobectomy for bronchiectasis, designed to obviate the flapping mediastinum, the closed pneumothorax, empyema and spreading mediastinitis, by doing a preliminary extrapleural thoracoplasty and at the time of the lobectomy bringing the ligated stump of the lobe outside of the pleura to be discharged into the dressings. He reports one case so treated.

Hedblom[46] reports a series of ten cases of diffuse bronchiectasis in which operation was done by graded extrapleural thoracoplasty without a mortality. Six of these patients have good general health. Three raise a small amount of sputum every twenty-four hours. One has signs suggesting infection of other portions of the lungs.

Meyer[47] reports a most favorable outcome of a bronchiectatic pulmonary abscess simulating apical tuberculosis which recovered with a "lip fistula"—a permanent drainage tract much to be desired in certain cases. In speaking of abscess of the lung, Meyer[48] says,

> We must learn to refine the diagnosis and find out as soon as the patient comes under our care what type of suppuration we have to deal with. Radiography and bronchoscopy will aid the clinician.

Myerson,[49] in his contribution to the etiology of lung abscess following tonsillectomy, maintains that

> Lung tissue and smaller bronchial elements temporarily damaged by increased concentration and prolonged administration of ether, or permanently damaged by influenza pneumonia or tuberculosis indicate an inability to expel aspirated material. This involved area becomes the site of election of a suppurative lesion.

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43. Guibal, P.: Monograph, Paris, Masson et Cie, 1924.
44. Fronticelli, E.: Policlinico (Sez. prat.) **31**:771 (June 16) 1924.
45. Archibald, Edward: Canad. M. A. J. **14**:197 (March) 1924.
46. Hedblom, Carl: Graded Extrapleural Thoracoplasty in Treatment of Diffuse Unilateral Bronchiectasis, Arch. Surg. **8**:405 (Jan.) 1924.
47. Meyer, Willy: Bronchiectatic Pulmonary Abscess Simulating Apical Tuberculosis, Arch. Surg. **8**:407 (Jan.) 1924.
48. Meyer, Willy: M. J. & Rec. **119**:189 (Feb. 20) 1924.
49. Myerson, M. C.: Lung Abscess Following Tonsillectomy, Arch. Otolaryngology **1**:137-146 (Feb.) 1925.

Graham [50] during the last year has made a most valuable contribution to the surgery of chronic lung suppuration and reports twenty cases treated by cautery lobectomy; four of the patients died, one an operative death, the three others at a later time of some other disorder.

Lilienthal [51] earlier published a series of thirty-two cases of lung suppuration including (*a*) abscess, (*b*) abscess with bronchiectasis and (*c*) bronchiectasis, in many of which he did a lobectomy, with a mortality of about 50 per cent.

Schlaepfer,[52] in an article based on his studies in the surgical laboratory, says,

> In any case of unilateral chronic inflammation of the lung with evidence of a certain general resistance as manifested by fibrous tissue formation around the foci of infection, ligation of the pulmonary artery combined with resection of the phrenic nerve is very promising.

MALIGNANT NEW GROWTHS IN THE LUNG

Last summer, through the courtesy of Dr. Rudolph Matas, I was enabled with Drs. LeWald and Elwyn to study a primary tumor of the lung which extended outward and later eroded the rib. Through the courtesy of Dr. Quick another one was seen which presented a similar picture. Our comprehension of this subject is becoming more and more alert through the similarity of the roentgenograms in these scattered cases. These two and a recent one of Dr. Walton Martin all presented a similar picture.

Lilienthal, in his address before this association during its sixth annual meeting in Chicago called our attention to the fact that "we have at our command facilities for making a prompt working diagnosis, or even an accurate pathologic one, but the medical profession is nearly always slow to avail itself of new diagnostic procedures of a surgical nature"; he referred to roentgenology and bronchoscopy.[53] Yankauer has called attention to the frequency of a malignant growth as the basis of lung suppuration.

With Graham's [50] cautery lobectomy and the adjuvant of some form of irradiation an early diagnosis should lead to a certain percentage of cures. Keller has operated in one such case by the cautery method.

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50. Graham, Evarts: Cautery Pneumectomy for Chronic Suppuration of the Lung, Arch. Surg. **10**:392 (Jan.) 1925.

51. Lilienthal, Howard: S. Clin. N. A. **1**:1541 (Dec.) 1921.

52. Schlaepfer, Karl: Ligation of Pulmonary Artery of One Lung With and Without Resection of Phrenic Nerve, Arch. Surg. **9**:25-94 (July) 1924.

53. Lilienthal, Howard: Malignant Tumor of Lung, Arch. Surg. **8**:308 (Jan.) 1924.

Materna [54] says that the predominance of lung cancer is in males and that the right lung is especially the seat of the carcinoma. He calls attention to the fact that erroneous diagnoses are extremely frequent as the metastases very often give the first clinical sign, bone metastases being remarkably common. The clinical diagnosis can be given only through roentgen-ray examination. Sessa [55] describes with commendable caution the clinical and roentgen-ray findings in a case of probable primary carcinoma in the upper lobe of the right lung.

ECHINOCOCCUS CYST IN LUNG

In reporting a left sided unilocular echinococcus cyst, Gaehwyler [56] emphasizes the importance of diagnostic pneumothorax for obscure tumor cases.

Blanc-Fontacini [57] advocates opening these cysts by the two stage method after a costal resection, as the corticopleural echinococcus cysts rarely result in a spontaneous cure when they rupture into a small bronchus, on account of insufficient drainage, but rather they result in putrid infection.

MASSIVE COLLAPSE OF LUNG

Massive collapse of the lung has been reported by Elwyn [58] and by Lund and Ritvo.[59] Scott [60] presented a compilation of forty cases, four of which were his own. He calls it postoperative massive atelectasis, which appears the better term.

MEDIASTINUM

The value of posterior mediastinotomy has been emphasized by Lilienthal [61] and the technic carefully elaborated. The treatment of suppuration in the posterior mediastinum is dealt with in a most noteworthy manner by Lerche,[62] who reports six cases and presents clear illustrations. He advocates draining the retrovisceral space in the neck by an incision along the inner border of the sternocleidomastoid muscle down to the sternal notch; then "following the lateral aspect of the esophagus, the finger readily enters the posterior mediastinum."

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54. Materna, A.: Beitr. z. klin. Chir. **132**:708, 1924.
55. Sessa, P.: Radiol. méd. **11**:6-12, 1924.
56. Gaehwyler, M.: Schweiz. med. Wchnschr. **54**:815, 1924.
57. Blanc-Fontacini, T.: Medicina Ibera **18**:733, 1924.
58. Elwyn, H.: Boston M. & S. J. **190**:1108 (June 26) 1924.
59. Lund, C. C., and Ritvo M.: Boston M. & S. J. **190**:1103 (June 26) 1924.
60. Scott, W. J. M.: Postoperative Massive Collapse of Lung, Arch. Surg. **10**:73-116 (Jan.) 1925.
61. Lilienthal, Howard: Posterior Mediastinotomy, Arch. Surg. **6**:274-281 (Jan.) 1923.
62. Lerche, William: Suppuration in Posterior Mediastinum, Arch. Surg. **8**:247-259 (Jan.) 1924.

Schmieden [63] reports a case of a large teratoma successfully removed from the anterior mediastinum. (In removing this tumor he found the pedicle of the lung elongated and compressed and the pericardium so firmly adherent to the tumor that it had to be partially removed with it.) He recommends the resection of the second to the sixth costal cartilage as this provides a good exposure. Heuer [64] reports the removal of a calcified cyst of the anterior mediastinum with a seven years' cure. The cyst was very adherent to the pericardium. He reports exploration of the posterior mediastnium for a tumor, which twelve days later at necropsy proved to be concomitant with an aneurysm of the descending aorta. Whittemore's [65] case of teratoma reported in 1923, although mentioned in a previous year, should be noted here. It undoubtedly had its origin in the mediastinum. Mediastinal glands due to Hodgkin's disease and lymphosarcoma are readily held in check, sometimes for years, by irradiation.

ESOPHAGUS

Benign strictures of the esophagus are successfully treated by a preliminary gastrostomy and the string sawing operation of Abbe, as well as orally by means of the esophagoscope and the Lerche dilator.

Strauss and Herr [66] present a new method of operating on congenital esophageal stenosis above the cardiac orifice, and King [67] lays claim to a new method of restoring the lumen in a case of impermeable stricture of the esophagus. Rovsing [68] contributes an antethoracic esophagoplasty and reports two successful cases and three still under treatment.

Pulsion diverticula are successfully treated by the two stage operation through the neck, although B. Anglesio [69] does not consider the two stages necessary; Fairen [70] recommends diverticulopexy with or without secondary extirpation; traction diverticula that had ruptured into the lung have been reported successfully treated by Sauerbruch. In idiopathic dilatation of the esophagus, the transdiaphragmatic anastomosis of the dilated esophagus with the stomach, as was done by Lambert, is to be kept in mind. Bull [71] presents a most comprehensive article on this condition and reports five cases of which four have been treated

63. Schmieden, V.: Arch. f. klin. Chir. **129**:657, 1924.
64. Heuer, G. J.: Ann. Surg. **79**:670 (May) 1924.
65. Whittemore, Wyman: Teratoma of Light Chest Cavity, Arch. Surg. **6**:282 (Jan.) 1923.
66. Strauss, A. H., and Herr, T. H.: Congenital Esophageal Stenosis Above Cardiac Orifice, J. A. M. A. **84**:501 (Feb. 14) 1925.
67. King, Edward: Surg., Gynec. & Obst. **39**:596 (Nov.) 1924.
68. Rovsing, Thorkild: Ann. Surg. **81**:52-58 (Jan.) 1925.
69. Anglesio, B.: Arch. ital. di chir. **9**:469, 1924.
70. Fairen, V.: Ann. d. mal. de l'oreille, du larynx **43**:44, 1924.
71. Bull, P. N.: Ann. Surg. **81**:59-93 (Jan.) 1925.

by means of subdiaphragmatic esophagogastrostomy. Reefing up the dilated esophagus transpleurally, as done by Willy Meyer, is another method of relief.

Rosenthal [72] cites three cases of so-called idiopathic dilatation of the esophagus coming under his observation in the Budapest Clinic.

The true test of thoracic surgery lies in the treatment of esophageal cancer. Here we have combined with the mechanical, physiologic and anatomic problems of thoracic attack the equally grave and depressing problem of dealing with cancer generally in a well advanced stage. Here we have the inertia of almost the whole medical and surgical profession, who regard this malady as without hope, and the shrinking on the part of the patient from undergoing an operation that invades the recesses of the most inaccessible region of the body. But who, after having watched patient after patient gradually sink from health into distress and from hope into apathy, waiting for the inevitable end, will not consider it preferable for the patient to take the chance of an operative cure even at the risk of a still high mortality? I do not believe the suffering accompanying a thoracic resection in any way compares with the weeks and months of substernal burning and pain which the palliative treatment entails. And now this field which seemed without cheer has had another hopeful ray cast on it. Eggers,[73] following the method of Torek,[74] has a patient alive for more than a year. These cases together with the operative recoveries of Zaiijer,[75] Lilienthal [76] and Hedblom [77] have rather swung the balance away from attempted cures through physiotherapeutic means—by which no permanent cures have been so far reported. We must admit, however, that most patients fear a sudden operative death more than a lingering medical dénouement alleviated with narcotic drugs.

Heuer, Andrus and Bull [78] report their application of the experimental transplantation of the diaphragm as an adjunct in the treatment of lesions at the lower end of the esophagus in man.

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72. Rosenthal, E.: Therapie der Gegenwart **65**:346, 1924.

73. Eggers, Carl: Resection of the Thoracic Portion of the Esophagus for Carcinoma, Arch. Surg. **10**:361-373 (Jan.) 1925.

74. Torek, Franz: Carcinoma of the Thoracic Portion of the Esophagus, Arch. Surg. **10**:358 (Jan.) 1925.

75. Zaiijer, T. H.: Nederl. Tijdschr. v. Geneesk. **58**:2540, 1922; Beitr. z. klin. Chir. **83**:2, 1913.

76. Lilienthal, Howard: Ann. Surg. **74**:259-279 (Sept.) 1921; ibid. **76**:333-334 (Sept.) 1922.

77. Hedblom, C. A.: Evolution of Thoracic Surgery as a Specialty, Arch. Surg. **10**:383 (Jan.) 1925.

78. Heuer, G. J.; Andrus, W., and Bull, H. G.: Ann. Surg. **81**:273-286 (Jan.) 1925.

PERICARDIUM

During the last eighteen months the pericardium has received sustained attention. The cases of drainage of the pericardium of Whittemore and of Pool have been previously published. Delorme,[79] in speaking of cardiac adhesions and cardiolysis, says that this operation (cardiolysis) is entitled to rank first in order in the surgical treatment of cardiac adhesions. The liberation of the heart from adhesions of extensive type gives a remarkable and permanent definite result. It should be resorted to at a time near the onset in pericarditis following ordinary infections. It constitutes the supplementary operation of pericardiotomy in purulent pericarditis. It may also be beneficial in later cases. As far as possible the pleura should not be incised. This can be avoided by pushing back the pleural border, leaving it concealed under the detached triangularis sterni muscle. Bourne [80] has compiled twenty-three cases from the literature with but two deaths, and adds two successful cases of recovery after cardiolysis.

Marvin and Harvey [81] urge that the operation of cardiolysis constitutes a very valuable therapeutic measure, and one that should be kept in mind by internists and surgeons. They maintain that from a technical standpoint the operative procedure is a simple one and may be done under infiltration and block anesthesia.

Schmieden [82] divides the indications for the treatment of contracting pericardial adhesions by means of extirpation of the pericardium into four stages: (1) total but soft adhesions; (2) more serious, the area involved in the adhesions passing into cicatricial callous thickening or even calcification; (3) the contractile form of adhesions in which systolic contraction is possible but the heart persists in a kind of permanent systole, the diastole however gradually becoming impossible; (4) thickening of the mediastinum, which shares in the consolidation through extrapericardial contraction of scar tissue. The last has an absolutely unfavorable prognosis. He reports three patients operated on: One had a complete cure, one lived several years and one died in consequence of degeneration of the heart muscle. In another article [83] he advocates, and quite with reason, beginning the operation of pericardiotomy with a large thoracic window. The third to the sixth ribs may be resected beyond the cartilages, and part of the sternum in an arc beyond the midline.

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79. Delorme, E.: Progr. Med. **2**:457, 1924.

80. Bourne, G.: Quart. J. Med. **17**:179 (Jan.) 1924.

81. Marvin, H. M., and Harvey, L. C.: Surgical Treatment of Adherent Pericardium, J. A. M. A. **82**:1507 (May 10) 1924.

82. Schmeiden, V.: Acta chir. Scandinav. **57**:268, 1924.

83. Schmieden, V.: Zentralbl. f. Chir. **51**:46, 1924.

Brooke [84] calls attention to the fact that in every case of osteomyelitis a sharp lookout should be kept for the appearance of a friction sound at the base of the heart. When it is definitely present the heart should be examined every six hours for the rub may change its position and fluid appear quite rapidly. If fluid is found by aspiration he advocates immediate pericardiotomy.

HEART

Angina Pectoris.—Sympathectomy for angina pectoris has been performed with increasing frequency,[85] and the combined resection of the sympathetic with the depressor nerve has been suggested for this condition and also for bronchial asthma. Reid and Andrus [86] present a compilation from the literature of fifty cases of sympathectomy for angina pectoris and twelve cases of depressor nerve resection for the same disorder. Willius [87] presents an article on angina pectoris and surgical conditions of the abdomen.

Valvular Disease.—It has been shown experimentally that surgical procedures within the heart of etherized dogs can be carried out under the guidance of vision and without undue haste.[88] Cutler, Levine and Beck [89] report four cases of mitral stenosis in which valvotomy was done. One patient recovered and was much improved. One lived four days, and two died the day of operation. This is a signal article.

In syncope the heart has been revived repeatedly by direct injections of epinephrin (1:1,000).[90]

DIAPHRAGM

Eventration of the diaphragm has been described as a separate entity and surgical plication has been performed to correct it.[91] This is not advised, however, unless the condition exists in extreme degree and then only after much consideration. A laboratory article with many valuable references on congenital deficiency of the diaphragm by Cutler and Cooper [92] has appeared.

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84. Brooke, R.: Lancet **2**:319 (Aug. 16) 1924.

85. Lilienthal, Howard: Cervical Sympathectomy in Angina Pectoris, Arch. Surg. **10**:531 (Jan.) 1925. Floercken, H.: Arch. f. klin. Chir. **130**:68-92, 1924.

86. Reid, M. R., and Andrus, W. D.: Ann. Surg. **81**:591 (May) 1925.

87. Willius, Frederick: Ann. Surg. **79**:524-537 (April) 1924.

88. Allen, Duff: Intracardiac Surgery, Arch. Surg. **8**:317 (Jan.) 1924.

89. Cutler, E. C.; Levine, A., and Beck, C. S.: Surgical Treatment of Mitral Stenosis, Arch. Surg. **9**:692-821 (Nov.) 1924.

90. Petit-Dutaillis, D.: Paris méd. **2**:30 (July 5) 1924. Raeschke, G.: Zentralbl. f. Chir. **51**:1628 (July 26) 1924.

91. Verbrycke, J. R.: Surg., Gynec. & Obst. **40**:415 (March) 1925.

92. Cutler, E. C., and Cooper, H. F. S.: Arch. Surg. **8**:506 (March) 1924.

The advance in thoracic surgery cannot be complete in itself; it is interwoven with the increased knowledge of the physiology of the thoracic mechanism, the increased knowledge of the pathology found there and the additional facilities to make accurate and early diagnosis. Added to this comes the follow-up and the evaluation of procedures, as indicated by the relative prolongation of life and the relative comfort afforded by diversified means of treatment of a given condition. All these are joined in this complex borderland.

Robinson [93] in 1922 said:

> Just why the progress in the chest wall caving-in operation is yet tardy, it is difficult to explain. The number of so-called cases and the many instances of great symptomatic relief would seem to be sufficient to warrant a more prevalent employment of such operations. And yet in a period of about twenty years, comparatively little has been done. Sauerbruch's Clinic at Zurich is watched with interest; but elsewhere the statistics are fragmentary. Many individuals might report, or have reported, from five to fifteen cases. If any well-trained American surgeon would devote himself exclusively to the study of the extrapleural surgical therapy of pulmonary tuberculosis, in conjunction with the director of a large tuberculosis sanatorium, I believe that, in a comparatively short time, his results would be so beneficial that a large surgical clinic would be established for this form of therapy.

These sentences furnish material for grave reflection. May the latter part of this quotation prove to have been prophetic. May we have better cooperation in all branches of chest pathology. Then each year we may expect more from thoracic surgery. Each year some new problem seeks solution. In the light of retrospect are cast the shadows of coming achievement.

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93. Robinson, Samuel: Thoracic Surgery, Arch. Surg. **6**:254 (Jan.) 1923.

ASPIRATION

EXPERIMENTAL STUDY *

WILLIS S. LEMON, M.D.
ROCHESTER, MINN.

For the last fifty years attention has been repeatedly directed to the appearance of pulmonary infection, especially as a sequel to surgical operation. How important a rôle pulmonary complications in general may play is best illustrated by reference to statistics gathered from foreign and American institutions. It is to be expected that one in fifty patients operated on will develop some type of pulmonary complication and that one in 185 will die from it. Deaths due to pneumonia alone following operations of all types are approximately 0.5 per cent., while the morbidity percentages are approximately 1.12 per cent. for general surgery and 4.4 per cent. for laparotomies.[1]

Cutler and Hunt [2] assert that 2 per cent. of all patients operated on, 4 per cent. of all patients who have abdominal operations, and 8 per cent. of all patients who have epigastric operations develop pulmonary complications.

In reviewing the extensive literature that is connected with the study of postoperative pulmonary disease, only two research workers have been found who approached the problem experimentally by a method at all similar to that used in this study.

Hölscher [3] prefaced his work by quoting authorities sponsoring two opinions as to postoperative infection of the lung: one that the infection is due to ether vapor irritating the mucous membrane, and the other that it is due to the aspiration of mucus from an unsterile mouth. He experimented on dogs and guinea-pigs and used gentian violet as an indicator. In six of twelve dogs, the dye was found in the smallest bronchi; in three, only in the larynx and trachea; in one case only in the larynx and upper portion of the trachea, and in two cases in the larynx only. Various positions of the body and of the head on the table

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* From the Division of Medicine, Mayo Clinic, and the Division of Experimental Surgery and Pathology, the Mayo Foundation.

1. Lemon, W. S., and Mahle, A. E.: Gangrenous Type of Postoperative Pneumonia, Southwestern Med. **8**:536-552 (Nov.) 1924.

2. Cutler, E. C., and Hunt, Alice M.: Postoperative Pulmonary Complications, Arch. Surg. **1**:114-157 (July) 1920; Postoperative Pulmonary Complications, Arch. Int. Med. **29**:449-481 (April) 1922.

3. Hölscher, Richard: Experimentelle Untersuchungen über die Entstehung der Erkrakungen der Luftwege nach Aethernarkose, Arch. d. klin. Chir. **57**:175-232, 1898.

were employed. In the second division of his work comparisons of various anesthetic materials were made and their effects on the mucosa with respect to the production of inflammatory reaction or of irritation and the production of increased amounts of mucus. He arrived at five conclusions:

1. Other than the slightly altered secretion, there is no evidence that the ether vapor causes any inflammation of the tracheobronchial mucous membrane.

2. During ether anesthesia, tracheal râles are due to the aspiration of mouth secretion and they can be avoided by proper technic, which includes siutable methods to allow the mucus to flow from the mouth, turning the head to the side and keeping the jaw elevated.

3. Most infections of the lung after ether anesthesia are due to aspiration from the mouth.

4. The action of the cilia of the trachea and bronchi is not disturbed during ether anesthesia.

5. The secretion of mucus during ether anesthesia is influenced not only by local stimulation but also in a small degree by central stimuli.

Myerson [4] conducted his experiments directly on patients undergoing operation. He examined bronchoscopically 100 patients undergoing tonsillectomy under light anesthesia. Twenty-two retained their cough reflex, and of these eighteen had no blood or mucus in the tracheobronchial tract, and four had blood or mucus below the larynx. The remaining seventy-eight did not cough during the operative procedure, although they retained the laryngeal reflex. Six only of these were free from blood or mucus in the tracheobronchial tract.

A comparison of these figures reveals the fact that in the first group, cough reflex being retained, only 18 per cent. of the patients had aspirated mucus below the larynx, whereas in the second group, the cough reflex having been lost, five times as many, or 90 per cent., had aspirated mucus into the tracheobronchial tract.

Myerson believes that blood mixed with mucus does not exert sufficient stimulus to set the cough reflex in action.

In 1924, Mahle and I [1] observed, in the Mayo Clinic, five types of pneumonia, illustrating the paths by which it is believed infections approach the lung and produce disease within that organ. These paths are the blood stream, the lymphatics, and the great air passages themselves.

When such wide and easily traversed parts may be chosen it is not surprising that all are employed. It is not likely, therefore, to be true

4. Myerson, M. C.: Bronchoscopic Observations on the Cough Reflex in Tonsillectomy Under General Anesthesia, Laryngoscope **34**:63-68 (Jan.) 1924.

that these infections will be due to bacteria traveling by any single route to the lung. Cutler and Hunt [2] believe that most postoperative pulmonary morbidity is due to the hematogenous path of travel; this is undoubtedly often true.

The instances of particular interest were those in which it seemed that the aspiration of infected material, by way of the respiratory channels, was the more likely. In many instances it was impossible to prove definitely that these pulmonary infections were due to aspiration, although clinically and pathologically it seemed probable.

In order to submit the question to experimental proof, work was begun with the purpose of: (1) learning whether or not aspiration did occur when an animal was anesthetized; (2) discovering some of the factors that were necessary to permit of aspiration; (3) evaluating the accidents that may occur during anesthesia and their relationship to aspiration, and (4) learning the result of ether anesthesia on some of the recognized protective mechanisms of the lung.

TECHNIC

The present work was somewhat varied in character and may be generally classified in eight series.

There was no desire to compare the various types of anesthetics, and throughout all the experiments ether was used, because it effectually produces narcosis and eliminates cough and pharyngeal reflex. Dogs alone were used in the experiments as seeming to be the best laboratory animals.

As an indicator that would be visible to the naked eye when examining the gross specimens of trachea and lung, gentian violet and India ink were employed, and as an indicator for the purpose of demonstration and for illustrating the work, other opaque substances. These were of three varieties and of widely varying specific gravity. In one series of animals, a 20 per cent. suspension of bismuth was employed; in a second series silver iodid emulsion, and in a third lipiodol. The latter when warm floats on water. Records of roentgen-ray findings of each experiment were kept, of the animal's chest, and of the lungs after the trachea was tied and they were carefully removed. The latter are best suited for illustration.

SERIES 1. EXPERIMENTS IN THE INCLINED POSITION WITH FEET LOWEST

A series of dogs were etherized and placed in the head up position at an angle of less than 5 degrees. The nose was maintained perpendicular to the long axis of the body. A variable amount, from 20 to 40 c.c., of a 20 per cent. suspension of barium sulphate was slowly allowed to drip into the animal's mouth. In most instances it was slowly dripped into the cheek by separating the lips and drawing them away from the teeth. This was instilled at a rate not much in excess of

the rate at which saliva is often produced. Gentian violet had been added to the barium suspension to act as a visible indicator. The barium provided an opaque medium so that roentgenographic studies could be carried out.

The animals were maintained under surgical anesthesia for a period varying from twenty minutes to an hour. Animals were killed by deepening the anesthesia, by clamping and tying the trachea about midway between the larynx and bifurcation, or by bleeding and then ligating the trachea. In only two instances did aspiration fail to take place.

Fig. 1.—Appearance of trachea and lungs in Experiment 1.

TYPICAL EXPERIMENTS

EXPERIMENT 1.—Dog 1 was etherized, placed at an incline of approximately 5 degrees with feet down and head at right angles to the long axis of the body. The barium mixture was administered as follows: Anesthesia, 10:45; 10:48, 5 c.c. of barium suspension, with gentian violet; 10:49, 5 c.c.; 10:53, 5 c.c.; 10:55, 5 c.c.; 10:57, 5 c.c.; 10:59, 5 c.c.; 11:01, 5 c.c. At 11:04, the animal was killed by overetherization.

The trachea was ligated and the lungs were carefully removed. The trachea and bronchi were opened to the termination of the bronchi. Large amounts of barium were found which could be traced to the very finest divisions (Fig. 1).

EXPERIMENT 2.—Dog 2 was etherized in the same posture of body and head. A similar barium suspension was administered, 4 c.c. every two minutes until 50 c.c. had been given. It was poured into the mouth and the side of the lips to simulate mucus. The animal was killed with ether a few minutes after completion of the administration of the suspension.

Fig. 2.—Appearance of trachea and lungs in Experiment 2.

The trachea was ligated and the lungs carefully removed. When the trachea and bronchi were opened, a large amount of barium was found in both. The gentian violet dye was found to have extended beyond the termination of the barium and had progressed to the furthermost parts of the bronchus (Fig. 2).

EXPERIMENTS WITH ALTERED TECHNIC

EXPERIMENT 3.—Dog 3 was etherized and placed on an air incline with the head elevated 11 cm. above the feet, the head to the side, the jaw held in position, and no sagging allowed. A centrifuge pump exerted suction through a large catheter placed deep in the pharynx. Each five minutes 5 c.c. of

barium suspension was instilled into the mouth by separating the lips and allowing it to flow downward from the cheek. A total of 40 c.c. was given in forty minutes. The trachea was exposed and found to be deeply stained with gentian violet. It was severed and a glass tube tied into its distal end so that the anesthetic could be continued. Very fine charcoal powder was placed on the mucous membrane of the opened proximal portion but no movement of it was observed. The dog was killed by bleeding an hour after the commencement of anesthesia.

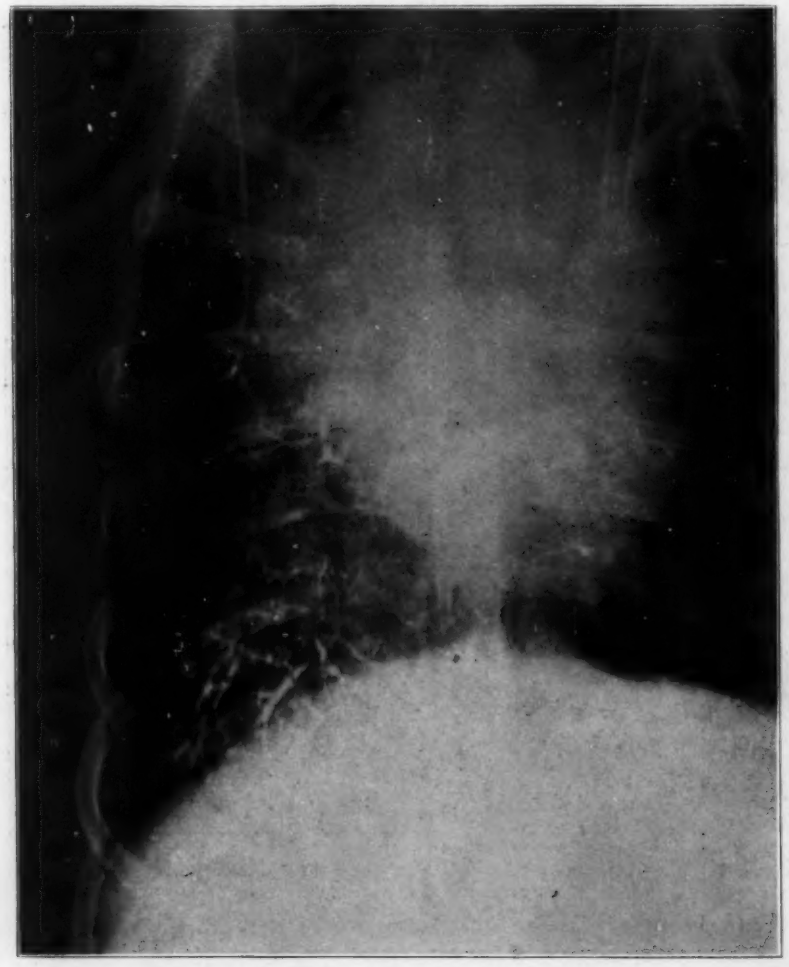

Fig. 3.—Appearance of trachea and lungs in Experiment 3.

EXPERIMENT 4.—The posture, the administration of the suspension, and the use of centrifuge pump were repeated in Dog 4. Anesthesia was maintained at surgical requirement and was without incident throughout. The trachea was exposed and incised, and it was observed by the stain that the dog had aspirated into his trachea. A glass tube was inserted entirely into the trachea after the mouth and pharynx had been thoroughly dried out with the suction pump. Suction was

discontinued; then 5 c.c. of barium suspension was given and aspiration observed through the glass tube. Regardless of the position of the dog's head, mucus was observed moving upward and downward with each respiratory phase, in spite of variation in the effect of gravity induced by altering the inclination of the table.

The stained mucus could be easily seen against a background of white formed by inserting paper behind the glass. There seemed to be very little barium in the aspirated material. It was almost entirely mucus stained with gentian violet.

Fig. 4.—Appearance of trachea and lungs in Experiment 4.

The movements were rhythmical, upward and downward with expiration and inspiration, but with a gradual, although inevitable, trend downward toward the bifurcation. As certain distinguishable portions slipped slowly from view, a new supply appeared from the larynx and made the downward flowing stream continuous. The dog was killed by bleeding. The duration of the experiment was one hour and twenty minutes.

In one dog of this series it was found that the dye had extensively colored the mucous membrane of the trachea and bronchi, and had extended up into the bronchi of the upper lobes for a distance of 4 or 5 cm. from the bifurcation. The

mucous membrane of the bronchi of the lower lobes, however, was stained to the periphery of the lung, having extended beyond the limits of the barium so that there was much more involvement of the lower than the upper lobes of these lungs (Fig. 3).

This observation holds good in practically every instance. The stream of mucus flowing downward meets the angular projection of the bifurcation, divides,

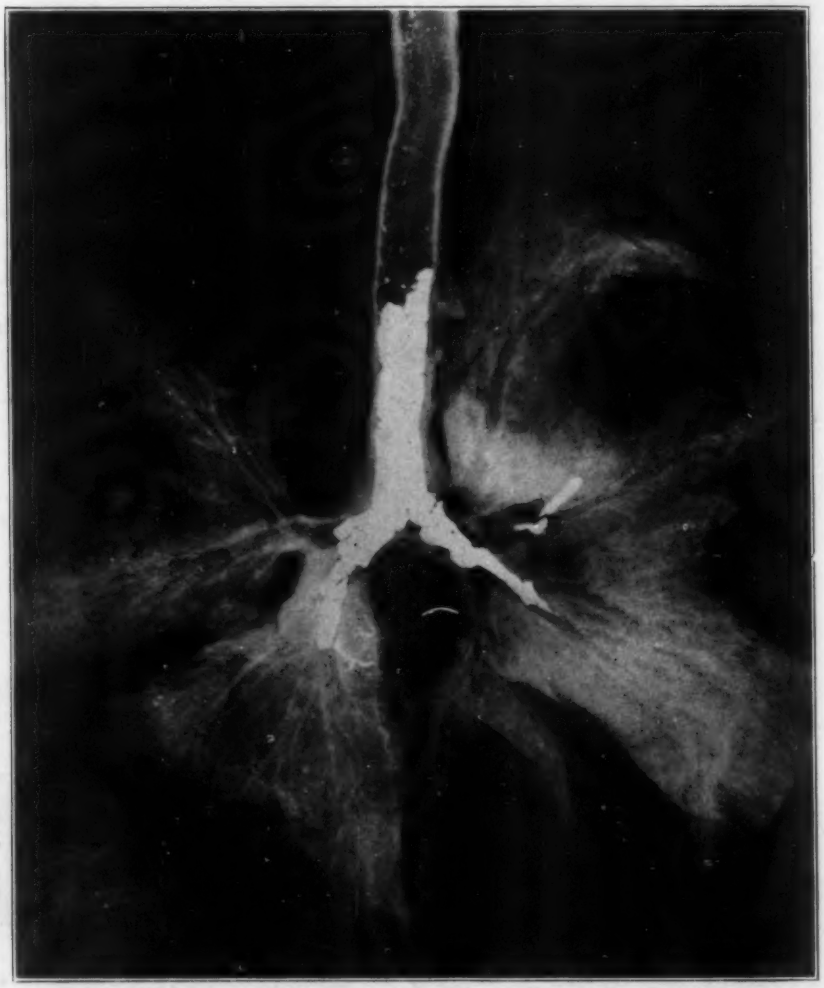

Fig. 5.—Appearance of trachea and lungs in Experiment 5.

fills the main bronchi and, flowing ever downward, fills the lesser bronchi apparently following the path where the amplitude of movement is greatest, namely, into the lower lobes.

SERIES 2. EXPERIMENTS IN THE HORIZONTAL POSITION

A technic similar to that in Series 1 was employed except that the dogs were placed on a horizontal table. The position of the head varied from the straight line with the body, muzzle up, to the flexion of the neck with the muzzle at right

angles to the line of the body. In every instance the angle of the jaw was supported and the mouth kept closed. Four experiments are described in two divisions.

HORIZONTAL SUPINE POSITION, HEAD IN STRAIGHT LINE WITH BODY AND MUZZLE UP

EXPERIMENT 5.—Dog 5 was given 20 per cent. barium suspension in amounts of 5 c.c. each five minutes for forty minutes. The dog was kept under uni-

Fig. 6.—Appearance of trachea and lungs in Experiment 6.

formly light anesthesia throughout the whole period. He swallowed on one occasion, and barium was found in the stomach. The trachea was tied in the usual manner. Only a small amount of barium was found in the trachea (Fig. 4).

EXPERIMENTS 6 and 7.—The technic was the same except that surgical anesthesia producing complete relaxation was maintained in Dogs 6 and 7. The

anesthesia was without incident. The dogs were killed by bleeding. Barium was found as low as the bifurcation of the trachea, and there was a small amount in the main division of the bronchi of the lower lobe (Figs. 5 and 6).

HORIZONTAL SUPINE POSITION, HEAD HELD TO SIDE

EXPERIMENT 8.—In Dog 8, satisfactory surgical anesthesia was maintained. After twenty minutes there was a period lasting about one minute when deep labored breathing occurred. The dog received 40 c.c. of barium suspension, 5 c.c.

Fig. 7.—Appearance of trachea and lungs in Experiment 7.

being given every five minutes. A large amount of mucus drained from the dog's mouth during the anesthesia. After forty minutes the dog was killed by bleeding. When the throat was opened, the trachea was seen to be deeply stained by the gentian violet in the suspension. Barium was found below the bifurcation and in the bronchi of the lower lobes.

A series of three dogs was employed in which intratracheal auto-inhalation etherization was used. The barium suspension was given with the usual technic,

with the exception that in the first dog 5 c.c. was given every five minutes until a total of 40 c.c. had been given; in the second, 2.5 c.c. was given every five minutes until 20 c.c. was given, and in the third, 1.25 c.c. was given every five minutes until 10 c.c. was given. The tracheal tube was removed at the close of the experiment, the trachea tied and the lungs carefully removed. In no instance

Fig. 8.—Appearance of trachea and lungs in Experiment 8.

did aspiration occur. This small series was used to determine the efficiency of the intratracheal method of anesthesia.

In each instance a large amount of mucus was secreted and drained from the lower side of the mouth. Less bismuth was found in the lungs in these experiments than in Series 1 in which the head was elevated. In some instances the trachea was entirely normal; in others there was no barium but the tracheal mucosa was stained for a distance of an inch or two (2.5 or 5 cm.) below the larynx. In all instances, regardless of position, the stain proceeded further into

the trachea, bronchi, or periphery of the lungs than did the barium, evidently being much more easily carried either by the mucus (Fig. 7) or by phagocytic cells.

SERIES 3. EXPERIMENTS WITH ANIMALS AT VARIOUS DEGREES OF INCLINATION, HEAD LOWEST AND IN VARIOUS POSITIONS IN RELATION TO TRUNK

FOOT OF TABLE TEN CENTIMETERS ABOVE HEAD, HEAD TO SIDE

EXPERIMENT 9.—The technic used for Dog 9 was similar to that of former experiments. Large amounts of mucus dripped from the mouth during satis-

Fig. 9.—Appearance of trachea and lungs in Experiment 9.

factory surgical anesthesia. When the throat was opened the trachea could be seen deeply stained. On examination, it was found to be filled with mucus that could be followed into one of the main bronchi (Fig. 8).

In these experiments one animal died when under only light anesthesia, and at necropsy the larynx was found to be completely plugged with thick, tenacious mucus, regardless of the fact that large amounts dripped from the mouth during the course of the anesthesia. In these examples aspiration occurred against the

force of the gravity, and equally regardless of the opaque medium used. Figure 9 shows result after using silver iodid emulsion according to the following technic:

FOOT OF TABLE TWENTY-NINE CENTIMETERS ABOVE HEAD, HEAD TO SIDE

In another group of this series silver iodid emulsion, given in 2 c.c. amounts every five minutes for forty minutes, was employed, as well as the barium suspension given according to the standard technic. In no instance did aspiration occur.

Fig. 10.—Appearance of trachea and lungs in Experiment 10.

SERIES 4. EXPERIMENTS RELATIVE TO USE OF SMALLER AMOUNT OF OPAQUE MATERIAL OF LESS SPECIFIC GRAVITY

Warmed lipiodol in amounts varying from a total of 5 c.c. to 10 c.c. was instilled into the mouth in equal quantities over a period of forty minutes. The amount introduced with a medicine dropper approximated 0.5 to 1 c.c. every five minutes. It was thought that so small a quantity could not possibly affect the total quantity of secretion. Moreover, it was believed that it could have no effect in stimulating the production of mucus, nor could it materially change the specific gravity of the secretions. It was found that it flowed freely when warmed and was then observed to float on water.

EXPERIMENT 10.—Dog 10 lay on an inclined plane with the head 10 cm. above the feet. Surgical anesthesia was maintained during which six equal instillations of lipiodol were given until a total quantity of 5 c.c. had been administered. The animal was killed by bleeding. Figures 10 and 11 show the aspirated material in the trachea and bronchi both before and after removal of the lungs from the body. In this experiment the left lower lobe was chiefly affected by aspiration. Lipiodol can be seen in the stomach. It will be observed that the bronchi are filled to their finest divisions.

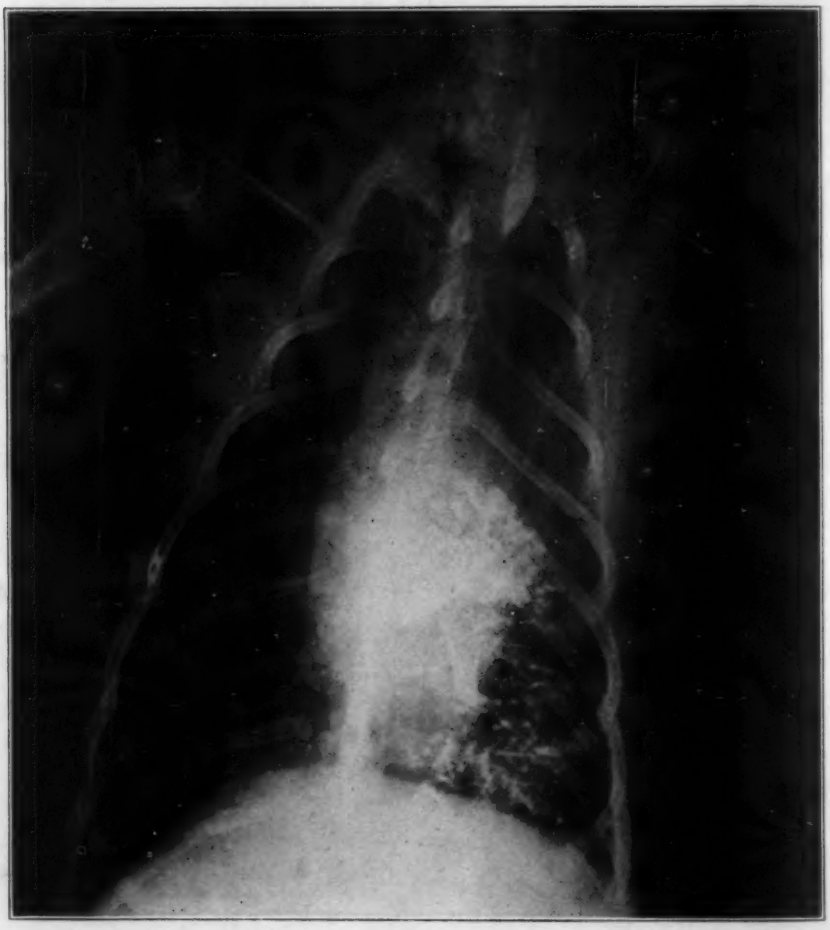

Fig. 11.—Appearance of trachea and lungs in Experiment 11.

SERIES 5. EXPERIMENTS RELATIVE TO EFFECT OF VOMITING ON ASPIRATION DURING ANESTHESIA

Various expedients were employed because it was difficult to induce vomiting in the normal dog during anesthesia. Apomorphin was injected into two animals after the stomach had been filled with barium mixture, one by the use of the stomach tube and the other by injecting directly into the stomach with a syringe

and medium sized needle. Both experiments were failures because vomiting did not occur. Irritation of the esophagus with a brush likewise failed to produce vomiting.

DOGS IN HORIZONTAL POSITION, HEAD IN STRAIGHT LINE, ANESTHETIZED THROUGH INTRATRACHEAL TUBE

Forty cubic centimeters of the bismuth mixture was placed in the mouth to simulate vomited material. The anesthetic was kept up for from ten minutes to

Fig. 12.—Appearance of trachea and lungs in Experiment 12.

one hour when the tube was removed and the trachea clamped and tied. The trachea was divided about midway between the larynx and the bifurcation. In each of the three animals, in both proximal and distal portions of the trachea, bismuth solution was seen and the mucous membrane was stained with gentian violet, but no evidence of either could be discovered as low as, or beyond, the bifurcation of the trachea.

EXPERIMENT 11.—Dog 11 was etherized and placed on the left side with the head turned well to the left throughout the period of the experiment. A stomach tube was passed into the stomach through an abdominal incision, and 50 c.c. of barium mixture was placed in the stomach. Some of this escaped from the mouth, but ten minutes later 25 c.c. was passed through the tube. The animal was killed and necropsy performed immediately. The trachea was tied midway between the larynx and the bifurcation. Mucus mixed with bismuth was seen at the point of section. On roentgen-ray examination, fine particles of bismuth could be detected in the smallest bronchi of the right lung and occupying the periphery of each lobe.

Fig. 13.—Appearance of trachea and lungs in Experiment 13.

EXPERIMENTS 12 and 13.—Dogs 12 and 13 had been operated on previously and each had a gastric fistula through which a tube was passed into the esophagus. Through this 100 c.c. of the barium mixture was passed in four injections of 25 c.c. each, allowing five minutes between each injection. Animals were allowed to continue under the anesthesia for fifteen minutes before being killed. The barium mixture passed upward into the mouth in a way that simulated vomiting. The roentgenograms show the extent of aspiration, the barium virtually making a cast of one lobe in each lung (Figs. 12 and 13).

SERIES 6. EXPERIMENTS TO PROVIDE MATERIAL FOR HISTOLOGIC STUDY

EXPERIMENT 14.—Dog 14 lay on an inclined plane with the head of the table 10 cm. higher than the foot, and held to the side. Forty cubic centimeters of a mixture of 20 per cent. barium and India ink was given in doses of 5 c.c. every five minutes.

When the trachea was opened, mucus stained black could be seen filling the trachea and passing downward to the bifurcation. Here the mucus flowed in

Fig. 14.—Appearance of trachea and lungs in Experiment 14.

two directions filling the main bronchi of the lower right and lower left lobes (Fig. 14). It passed so deeply into the bronchi that the finest scissor points could not be inserted into their lumen for further opening of their walls. However, on gently withdrawing the points from these small bronchi, tenacious threads of blackened mucus, often 1 cm. in length, came away. The cut surface of the lung in its distal portions was mottled with tiny black spots representing

Figure 15

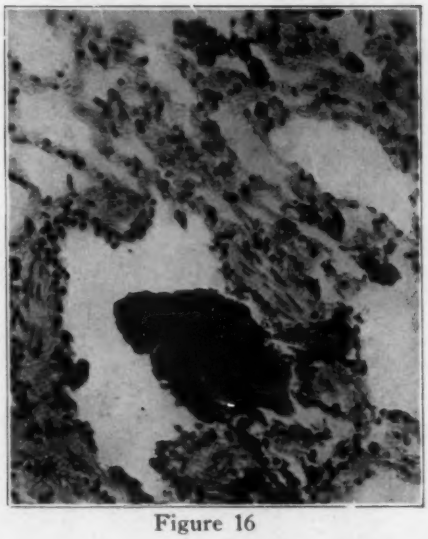

Figure 16

Fig. 15 (Experiment 14).—Pleural surface of lower lobe, showing India ink in alveoli, alveolar walls, phagocytic cells and in pleura itself; × 120.

Fig. 16 (Experiment 14).—India ink in bronchus, alveolus and alveolar walls; many of the phagocytic cells are filled with ink; × 150.

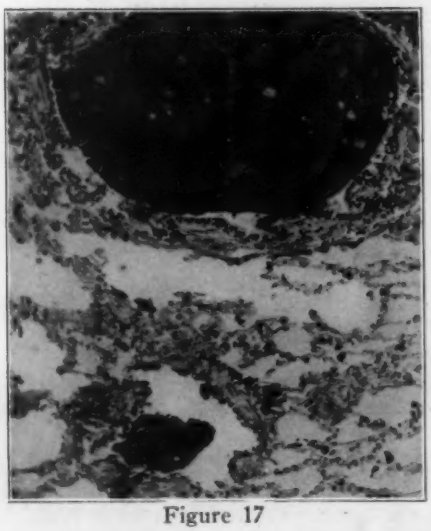

Figure 17

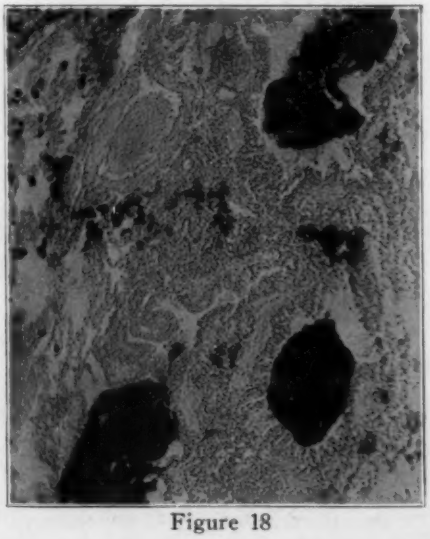

Figure 18

Fig. 17 (Experiment 14).—Larger bronchus filled with mucus and ink; ink also is seen in smaller bronchus, alveolar walls and phagocytic cells; × 75.

Fig. 18 (Experiment 14).—Three small bronchi filled with mucus and ink; ink is shown escaping from these bronchioles; × 500.

the finer division of the bronchi. In many instances these were removable in part by cohesion and traction and by this means could be distinguished from any possible effect of anthracosis (Figs. 15 to 20).

SERIES 7. EXPERIMENTS TO OBSERVE EFFECT OF ETHER ANESTHESIA ON MOVEMENTS OF CILIA

These experiments were done in various ways. At first, a section was cut from the trachea of the etherized dog. It was placed in salt solution and examined at once both microscopically and by use of a magnifiying glass through which particles of carmin or finely powdered charcoal placed on the mucosa could be observed. No movement of any kind was observed. Other experiments were undertaken in which the trachea was severed and the anesthesia continued through its distal portion. The proximal end was opened, laid flat, and on its slightly moist surface were placed very fine particles of powdered charcoal. In a number of dogs deeply anesthetized no movement was observed, while in two lightly anesthetized very definite upward movement could be observed, which ceased with the death of the animal, or if the circulation to the trachea was cut off or disturbed.

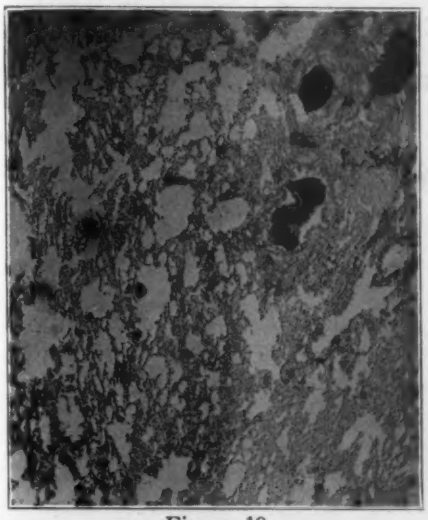

Figure 19

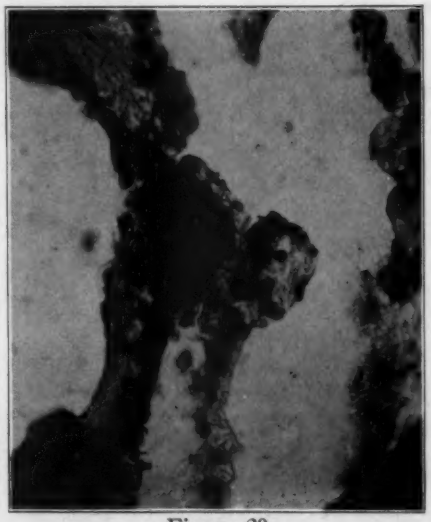

Figure 20

Fig. 19 (Experiment 14).—Three bronchi filled with mucus and ink, showing the amount of ink escaping into the alveolar walls; under low power.

Fig. 20 (Experiment 14).—Oil emersion view of alveolar wall, showing section so crowded with cells containing ink that many of the cell outlines are indistinguishable.

SERIES 8. EXPERIMENTS RELATING TO BACTERIAL FLORA DISCOVERED AT VARIOUS LOCALITIES FOLLOWING ASPIRATION

In these experiments a dextrose broth culture of *Bacillus prodigiosus* was used as an indicator because this bacillus is not commonly found in laboratories; it is not pathogenic and its color on solid mediums makes it easily recognizable. Amounts varying from 5 to 10 c.c. were instilled into the mouth. At necropsy the trachea was carefully seared, opened under sterile precautions and cultures made from the proximal portion as high as the larynx and from the middle portion. The trachea was then clamped and the lungs were carefully removed with careful aseptic precautions. Cultures were then made from the bifurcation

and from the depths of the bronchi. The lung surface was seared and opened and a culture taken from the lung itself. Positive returns were obtained from all five areas cultured. Besides *Bacillus prodigiosus,* various other organs were obtained from the mucus that had been aspirated, including staphylococcus and pneumococcus (Type I).

EXPERIMENT 15.—Dog 15 was etherized and placed on his back with the head elevated on a plane of 10 degrees and held at the side. A total of 5 c.c. of broth culture was dripped into the mouth through the cheek.

After cultures had been obtained, the lungs were opened with scissors and the bronchi laid open as far as their size permitted. Frothy mucus occupied the trachea as far as the bifurcation and could be seen well below it, chiefly in the bronchi leading to the lower lobes. When the bronchi were opened, frothy mucus could be distinguished as low as their fourth divisions.

EXPERIMENT 16.—The technic was varied in the one instance of Dog 16. The dog lay on its back with the head elevated 7.5 cm. above the body and turned to the side. Dextrose broth culture of *Bacillus prodigiosus* was dripped into the mouth each five minutes in doses of 2 c.c. until 10 c.c. had been used. In every instance the culture medium was allowed to flow down the cheek into the mouth. The anesthetic was kept up for forty minutes and the dog killed as usual by bleeding. In this animal, breathing became stertorous during the course of the anesthesia. The tongue was drawn forward to assist it in breathing, and on looking into the mouth while the head was well extended, one could observe the frothy mucus of the pharynx passing like a pendulum in and out of the larynx. Early in the experiment the dog was not deeply anesthetized and coughed a few times and could be seen to swallow. Mucus dripped from the mouth during the course of the experiment. Cultures were taken as before described and made on plain agar plates. After cultures had been taken the lungs were opened and a large amount of frothy mucus could be seen filling the trachea, the bifurcation area, and the bronchi below it.

COMMENT

When dogs under anesthesia lie on a plane inclined at various degrees and the head is elevated above the body, aspiration occurs, regardless of whether the anesthesia is light or deep. The position of the head relative to the body seems to make little, if any, difference in the amount of material aspirated. When there is a relatively large amount of fluid material in the mouth and pharynx, aspiration by suction pump fails to prevent the downward course into the lung. Undoubtedly it influences the amount of material that will pass down.

In almost every instance the coloring matter used proceeded deeper into the bronchi than did the heavier particulate matter.

Positive results were obtained when dogs were kept in the horizontal position on the table. The position of the head relative to the long axis of the body did not seem materially to influence the result. In this position there seemed to be much less aspiration when anesthesia was administered through a tracheal tube. In general, it is true that when employing this position, larger amounts of mucus escape from the dog's mouth, there are fewer audible tracheal râles, and less particulate matter is found in the lungs than when the dog is lying at an upward inclination.

With increasing downward inclination until the full Trendelenburg position was approached, less and less aspiration occurred. When the foot of the table was 28.75 cm. above the head, there were no instances in which mucus, stain or barium could be seen below the larynx. The force of the air current may operate to carry heavy material, such as bismuth or silver iodid emulsion, upward against gravity but a limit to its ability is soon reached.

It is evident that aspiration occurs regardless of the amount of indicator used or of its specific gravity. Aspiration of lipiodol occurred when a total amount of only 5 c.c. was used. It also occurred when only 5 c.c. of broth culture medium was employed. The bacteria introduced were recovered from all localities from the larynx to the lung.

Vomiting experiments showed that aspiration occurs when rather large amounts of fluid suddenly flow upward from the esophagus into the mouth. When animals were in a flat position and given their anesthetic through an intratracheal tube, they seemed to be protected to a marked degree. Only small amounts of "vomitus" could be discovered below the larynx.

Motility of cilia is preserved during ether anesthesia, but it is destroyed if the animal is deeply anesthetized or dies, or if the blood supply is disturbed, or if sections are removed for microscopic study.

There is ample clinical proof that aspiration into the lung takes place; otherwise water would not be found in the lungs of the drowned, foreign bodies would not be found in the air passages, and vomitus would not be discovered in the lungs of persons who have vomited following anesthesia. There are many other instances of aspiration, such as the finding of meat fibers in the lumen of the bronchi. The gastric odor has been distinguished and the yellowish green opaque discolorations of the gastric secretion have been seen. I have recently observed food pass from a tracheotomy tube.

Ordinarily aspiration does not occur, but MacCallum [5] thinks it does when the protective mechanism breaks down. He believes that certain conditions permit its occurrence, such as when patients are extremely ill, delirious, intoxicated or unconscious, when they are insane, and when anesthesia is induced for surgical reasons. Here, he thinks, vomiting gives an opportunity for the aspiration of gastric contents, and saliva drawn into the bronchioles carries with it bacteria of various kinds.

The mechanism of protection for the lung consists probably of at least four elements: the pharyngeal reflex, the cough reflex, the action of cilia whose rhythmic motion clears the trachea and bronchi of secre-

5. MacCallum, W. G.: A Textbook of Pathology, Ed. 2, Philadelphia, W. B. Saunders Company, 1920, p. 255.

tion, and some unknown tissue immunity that protects the lung against infection. It is, in all probability, analogous to that protecting the pelvis which makes operations in that portion of the body so uniformly safe.

It would seem probable that during anesthesia all but the two last factors are in abeyance. It may be that even these are depressed. From experiments with lower animals, such as frogs, we know that ether vapor stops movement of cilia. It would seem probable that the saturation used in producing anesthesia may depress, if not destroy, movement. If so, the third mechanism would be of less value in protection. The inherent immunity of the tissue may be affected, especially in those patients whose lungs have been for years the site of chronic disease.

It becomes apparent then that, from this cause alone, pneumonia should be expected after operation, that it should be more frequent in patients who take their anesthetic badly, who vomit during anesthesia, or are infected either in the upper air passages, mouth, tonsils, nasopharynx, in the bronchi or lungs. That bacteria placed in the mouth can be recovered even from the lung tissue itself, along with organisms usually found in the mouth, lends color to the supposition that many cases of postoperative pneumonia, in which there is pneumococcus Type IV or the saprophitic bacteria of Buday in the sputum, are in fact pneumonias due to aspiration. The work of Whipple,[6] Cleveland [7] and Sanford [8] bears out these conclusions.

SUMMARY

Experiments were conducted on dogs under ether anesthesia and an attempt was made, both in the administration of the anesthetic and in the posture of the animal, to simulate as nearly as possible the operative technic on human beings. The risk of extensive aspiration of mucus from the mouth into the lower respiratory passages was apparently increased by placing the subject on an inclined plane with the head elevated above the body. This risk seemed to become less and less as the plane passed through the horizontal to a decline, and to vanish when a full Trendelenburg position was reached. In all other postures, the dogs aspirated into the lower air passages or into the depth of the lungs, especially the lower lobes, regardless of whether the head was in a straight line with the body and muzzle up, or whether the head was held to one side.

The dangers were increased when light anesthesia was maintained so that the animal struggled, breathed stertorously, swallowed or vom-

6. Whipple, A. O.: A Study of Postoperative Pneumonitis, Surg., Gynec. & Obst. **26**:29-47 (Jan.) 1918.

7. Cleveland, Mather: Further Studies in Postoperative Pneumonitis, Surg., Gynec. & Obst. **28**:282-293 (March) 1919.

8. Sanford, A. H.: Personal communication to the author.

ited. It would therefore appear that the most scrupulous care should be taken during the early stages and when the subject is recovering from anesthesia.

That aspiration was not due to the material used for indicators was apparent because various opaque substances and variable amounts were employed and even the heaviest were carried upward against gravity and into the trachea and bronchi.

It seems certain that infection about the upper passages is an important consideration in all operations requiring general anesthesia as bacteria that had been placed in the mouth were obtained from the lung tissue, as well as organisms whose habitat is in the mouth.

From the results of these experiments it would seem that postoperative pulmonary infection may be explained, in part at least, as a result of infection carried to the lung in oral secretion, which has been aspirated by the force of the air current created when the chest expands in patients whose protective mechanism has been disturbed.

DISCUSSION

DR. WILLY MEYER, New York: Dr. Lemon's study shows what a patient might accumulate in the bronchial tree in the course of a general anesthesia sufficiently deep to allow a painless operation, if the chance for massive aspiration is given. It also again proves that aspiration is one of the chief dangers that the thoracic, and in fact every general, surgeon is facing in his daily work. It proves the correctness of the demand that we must have a well trained person to administer the anesthetic if the patient needs general anesthesia, and it emphasizes that the field of local and regional anesthesia should be enlarged as much as possible for the benefit of patient and surgeon alike.

One of the roentgenograms has particular interest to me. It is the one of which Dr. Lemon stated that he found nothing further down in the trachea and the bronchial tubes but that there was an accumulation of aspirated material right beneath the larynx. In this case the cause of death, I think, was spasm of the glottis, an occurrence frequently overlooked.

I can never forget an experience that I had in the early times of our experimental thoracic work. We did a pneumectomy on a dog within the experimental negative chamber in the presence of two surgeons of renown, who had come to see the operation.

I had my usual assistant, anesthetist and the same nurse in charge of the preparations and handing instruments. Everything went nicely and smoothly; the operation had been finished. When the dressing was being applied, the dog suddenly stopped breathing. No matter what we tried we could not relieve him. Thorough artificial respiration with the tongue well pulled forward, done with the apparatus, also proved without avail. It was evident that air pressure conditions within the thorax could not be held responsible for the sudden interference with respiration.

After our guests had left we tried to ascertain the cause of the embarrassing accident. We found the glottis completely closed in a tight reflex spasm, so tight that we did not succeed in separating the vocal chords bluntly.

I feel that this occurrence is not unfrequently the direct cause of some of those seemingly unexplainable deaths we may have on the table. I do not know

whether or not Dr. Lemon explained the findings in this case in the same way, but it seems to me that it represents a perfect specimen of that type.

Dr. Evarts A. Graham, St. Louis: I have noticed repeatedly the frequent association of nasal suppurations with suppuration of the lungs. I can't say offhand what this proportion is, but it is a very high proportion in chronic suppuration of the lungs. I have many times seen suppurations of the lung that have not been getting along satisfactorily after surgical drainage improve remarkably when suppurating sinuses were cleaned up.

I have no doubt that Dr. Lemon's explanation accounts for some of the remarkable recoveries of lung suppurations which occur after the suppurations about the nose are cleaned up.

Dr. Carl A. Hedblom, Madison, Wis.: Dr. Lemon's presentation seems to furnish experimental evidence in support of the view that postoperative pulmonary suppuration may be and often is due to aspiration of infected material during general anesthesia. The uniformity with which the foreign material found its way into the terminal bronchi in his experimental animals, however, seems to indicate either that there is a difference in the ease with which aspiration occurs in the dog and in the man, or that pulmonary infection in man following aspiration must depend largely on the nature or virulence of the infective organisms or on both. Otherwise one would be led to expect pulmonary infection as a rule following operations under general anesthesia, particularly in cases of operations in the semiupright or bolt upright positions, as in operations for goiter or for trifacial neuralgia. In operations for the latter condition, patients are often kept in the upright position for an hour or more under general anesthesia, yet pulmonary suppuration has not occurred in a large number of such cases in Adson's service at the Mayo Clinic. This experimental work certainly seems significant as supporting the view that most of the cases of pulmonary suppuration that follow nose and throat operations are due to aspiration of infected material. I hope that Dr. Lemon will pursue his investigations further in the direction of determining the rôle that different types of infection may play in the production of pulmonary lesions under the experimental conditions outlined.

Dr. David A. Stewart, Ninette, Manitoba: Dr. Lemon has shown how septic material is aspirated from the throat into the lungs during an anesthetic. I think Dr. Lemon will agree that those of us who see many pulmonary cases of various sorts, and bronchitic cases of all sorts, find a close association, apart from operation, between bronchitis and bad mouth, throat and nose conditions. When one finds chronic bronchitis, one can usually look above the clavicle for its causes and consider that the bronchial area has been made a sort of cesspool for septic material from above. The close association of a bad mouth with a septic lung may be apparent, as Dr. Lemon has shown, following operation, but it also is apparent, and often, without operation.

Dr. Charles Gordon Heyd, New York: We may gather from Dr. Lemon's experiments that there is an ebb and flow of mucus up and down the trachea. The question is, however, whether this occurs normally. Is not the graphic representation of lung injury in his pictures so striking that one wonders if the lung has any normal pulmonary tissue left after the forty minute etherization period? Again, the doctor used a barium solution. Is it a normal mechanism? If this ebb and flow of mucus occurs frequently during the course of normal surgical operations we should expect a much greater incidence of pneumonia than we have.

It would seem to me that in many, in fact, most of the ordinary cases of etherization there is a normal ebb and flow of mucus but the element that brings

out or initiates pneumonia depends on the character of the bacteria that are in the mucous current. It does not follow that the mere sedimentation of India ink or of barium or of any of the dyes necessarily proves that by itself the "ebb and flow" is the factor that produces pneumonia. If that were so, the position of the patient during etherization would be a factor in the production of pneumonia. Yet Dr. Lemon demonstrated that the mechanism occurred irrespective of gravity or position. If the ebb and flow mechanism were simply a gravity proposition we should naturally expect pneumonia or lung injury to be more frequent after operations performed in the semisitting position, such as we employ in thyroidectomy. In my own experience lung complications are relatively infrequent after thyroid surgery.

Another point to be mentioned is that with the giving of ether by rectum there is relatively little mucosal element in the ebb and flow mechanism, yet we find pneumonia probably as frequently after rectal anesthesia as we do after properly administered inhalation anesthesia. So far as the so-called ether or aspiration anesthesia pneumonia itself is concerned, it has been my experience that this type of pneumonia occurs more frequently when a patient has taken what we term a poor anesthesia. I myself am in the habit of expecting lung complications after an anesthesia in which there has been constant noise on inspiration and expiration or when the patient has shown marked tendency toward blueness. The incidence of this type of lung complication has been very much lessened since we have been putting the patient in Dr. Meyer's position—the prone position—immediately after operation.

It seems to me that this is a fruitful investigation that Dr. Lemon has made. I do not think, however, that the artificial conditions induced by allowing barium to flow into the mouth are comparable with what occurs in normal persons who are properly anesthetized.

Dr. Frederick T. Lord, Boston: One point I should like to make is the seasonal distribution of postoperative pneumonia. In over 70,000 operations at the Massachusetts General Hospital the percentage incidence by months of postoperative pneumonia is at its lowest level, 0.1 per cent., in July, rising thence steadily to its highest level, 0.5 per cent., in February, and as steadily declining thereafter. The incidence of this complication with us is thus five times greater in midwinter than in midsummer. In explanation, it seems probable that the seasonal trend is due to the prevalence during the winter months of more virulent types of organisms in the respiratory tract and their aspiration into the lung.

Dr. Edward W. Peterson, New York: I should like to ask Dr. Lemon to try the Bavarian mixture or the dye without any anesthesia at all, put into the mouth every five minutes, and to make a report sometime.

Dr. Willis S. Lemon, Rochester, Minn.: Experiments were done on normal unanesthetized animals and none of them showed any evidence of aspiration. Experiments also were done in which 10 per cent. cocain solution was painted on the back of the pharynx, but no aspiration resulted. A number of experiments were done using the Trendelenburg position; in none of these did aspiration occur. I agree with Dr. Lord about the incidence of epidemic pulmonary complications; in my own experience these complications have been similar in virulence, type of organism and mortality in patients who are in the hospital and those who are not. The aspiration type of pneumonia has to deal, however, almost entirely with Type IV pneumonia. This seemed to be proved by the work of Whipple and Cleveland and by the results of our own examinations. The mechanism illustrated is not intended to answer all problems of postoperative pulmonary complications, but I feel is an explanation of a definite fraction of them.

THE SURGICAL ASPECT OF MITRAL STENOSIS*

ELLIOTT C. CUTLER, M.D.
CLEVELAND

The field of cardiac surgery is rapidly enlarging. Including as it does the treatment of wounds of the heart and acute infections of the pericardium, the Brauer operation, the various recent procedures advocated for angina pectoris, and, finally, the subject of valvular stenosis, it bids fair to claim increasingly more attention at the hands of the surgeons. Some day perhaps there will be an association for cardiac surgeons, but until specialism is thus limited the American Association for Thoracic Surgery will remain the Mecca for all surgeons interested in various forms of cardiac surgery. We have little clinical experience to add to that already published,[1] but there have been certain experimental advances that lead us to hope that the two patients now ready for operation will give us more satisfactory results.

RATIONALE OF THE PROCEDURE

Any discussion of the possibilities of surgery in the treatment of mitral stenosis involves acceptance of the idea that mitral insufficiency is a far less serious condition than mitral stenosis. We must recognize from the beginning that any surgical reduction of a stenosis of the mitral valve will result in an insufficient valve. There is both clinical and experimental data to support this contention. I think you will agree that the condition of mitral insufficiency does occur without seriously affecting either the duration of life or the moderate activity of patients, provided the heart muscle is not greatly damaged. Many of us have seen patients with mitral insufficiency surviving to an advanced age. How different is the case with mitral stenosis, no matter how normal the muscle! How many of you have seen patients over 40 years of age suffering from this malady? And once the condition is established, is not your prognosis far more guarded and the patient's activities at once and permanently affected?

The experimental evidence that insufficiency is better tolerated than stenosis is equally striking; it has been shown repeatedly by physiologic observers. With the heart exposed, one may easily pass a ligature beneath the base of the valve cusps, which when drawn taut catches the

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* From the Lakeside Hospital and Department of Surgery, Western Reserve University School of Medicine.

1. Cutler, E. C.; Levine, S. A., and Beck, C. S.: The Surgical Treatment of Mitral Stenosis, Arch. Surg. **9**:689-821 (Nov.) 1924.

chordae tendineae and prevents the valves from opening widely. A fall in the pressure in the left ventricle and a rise in the pressure in the left auricle results. The former is recognized in patients suffering from mitral stenosis by the lowered systolic pressure, the latter by the condition of pulmonary congestion so frequently present in such cases. This rise in the auricular pressure results in a damming back of the blood in the pulmonic circuit, the deleterious effects of which have been carefully studied by Peabody, Drinker, and Blumgart.[2] If marked, it may seriously encroach on the alveolar space and interfere with the vital function of oxygen interchange. We have repeatedly performed such experiments.

Such *a priori* considerations led us to feel that an operative reduction of the stenosis, even if it results in a moderate insufficiency, is desirable.

We must now confront the problem of the accurate diagnosis of mitral stenosis. If we are to submit cases to the dangers of operation, we must be sure of our diagnosis. Heretofore, the accurate diagnosis of individual valve lesions has not been of prime importance. One might say it has been chiefly a matter of academic interest, for though the prognosis might be affected, the treatment is usually the same, aimed at the phenomenon of congestive failure common to all types of chronic valvular disease of the heart.

Considerable reliance may be placed on several factors in arriving at the diagnosis of mitral stenosis. The most critical point is the detection of a murmur in diastole. The position, duration, and character of this murmur will vary with the extent of the stenosis and the condition of the heart muscle. As a rule, the louder and longer the murmur, the greater the stenosis. It characteristically ends with crescendo and a sharp, snapping first sound. The incidence of fibrillation alters these sounds in degree and intensity and may cause them to disappear totally.

A palpable thrill in diastole at the apex is often present, but may be absent in cases with a high degree of stenosis. The roentgenogram and the electrocardiogram give evidence of great value. The roentgen-ray examination will usually demonstrate a prominent left auricle. The electrocardiographic tracings commonly show an altered P wave (notched or flat topped) and evidence of right ventricular preponderance.

However, even if we can properly diagnose the disease, there must be considerable care in the selection of the type of case to be submitted to operation. Rheumatic heart disease is a pancardiac condition. In some cases the pericardium, in others the endocardium or myocardium is chiefly or, indeed, solely involved. Obviously with all three portions

2. Drinker, C. K.; Peabody, F. W., and Blumgart, H. L.: The Effect of Pulmonary Congestion on the Ventilation of the Lungs, J. Exper. Med. **35**:77 (Jan.) 1922.

involved, surgery is of no avail. Surgery must be reserved for the cases of pure mitral stenosis in which the mechanical obstruction is the dominant feature, and in which the myocardium is relatively intact. Moreover, we should like to feel certain that the patient is past the stage of recurring febrile attacks so commonly seen in this disease.

HISTORY

Time does not permit us to review the interesting and important developments, both surgical and physiologic, that have finally led to operative procedures on the stenosed mitral valve. The idea undoubtedly came to many a physician before the time when Samways [3] and Brunton [4] proposed it. We should, however, acknowledge our debt to our physiologic colleagues who first devised instruments and methods for creating defects in the valves of the heart, and to our surgical forebears who first had the courage to suture the wounded human heart. To our generation, the tools and methods were available, and the pathway already had many sign posts indicating the safer road.

EXPERIMENTS

From the beginning, it was our hope to develop a method satisfactory for immediate application to human cases. We had already repeated the experiments of releasing an artificially created stenosis, and noted the improvement in the circulation that followed. The problem resolved itself into the task of devising proper and efficient instruments and a satisfactory and reasonably safe method of approach.

Our first experimental efforts were made on cats, dogs and goats, using small knives (Fig. 1) with a long slender shaft. These knives differed but little from those used by Klebs [5] in 1875, Cushing [6] in 1907, and Schepelmann [7] in 1912. Our efforts along these lines afforded us an opportunity to familiarize ourselves with methods of handling the heart, and gave us information of great value regarding the ability of

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3. Samways, D. W.: Cardiac Peristalsis, Its Nature and Effects, Lancet **1**:927, 1898; Correspondence, Lancet **1**:548, 1902.

4. Brunton, Lauder: Preliminary Note on the Possibility of Treating Mitral Stenosis by Surgical Methods, Lancet **1**:352, 1902.

5. Klebs, E.: Ueber Operative Verletzungen der Herzklappen und deren Folgen, Prag. med. Wchnschr. **1**:29-36, 1876.

6. Cushing, H., and Branch, J. R. B.: Experimental and Clinical Notes on Chronic Valvular Lesions in the Dog and Their Possible Relation to a Further Surgery of the Cardiac Valves, J. M. Res. **12**:471-486, 1907-1908.

7. Schepelmann, E.: Arch. f. klin. Chir. **97**:739, 1912; Herzklappen Chirurgie, Experimentelle Untersuchungen, Deutsch. Ztschr. f. Chir. **120**:562-579, 1912-1913; Versuche zur Herz-chirurgie, Arch. f. klin. Chir. **97**:739-751, 1912; Zur Chirurgie des Segelklappenstenose des Herzens, München. med. Wchnschr. **60**:47, 1913.

the heart to withstand trauma. We noticed that when a defect was created, the defect tended to enlarge rather than grow smaller, and that thrombi did not form at the site of injury except when infection was present.

At this stage of our investigations, the opportunity came to operate on a human being. In the first three cases small knives similar to a tenotome knife were used. Examination of the hearts of Patients 2

Fig. 1.—Instruments to section stenosed mitral valve; the knives were used in three human cases, the cardiovalvulotome, in two human cases.

and 3 demonstrated to us that such knives were insufficient for the task to be performed, and left us chagrined that we had failed to study more thoroughly the task at hand. A careful study of all the hearts with mitral stenotic valves that were available demonstrated forcibly the fact

that such diseased valves are thickened, sclerotic, and often contain deposits of calcium. Obviously, a thin knife manipulated under a great mechanical disadvantage could not section the majority of such valves.

These considerations led to the development of the cardiovalvulotome [8] (Fig. 1), an instrument composed of circular tubing, the distal portion of which can be approximated to the shaft of the instrument. The tip is a blunted point, the cutting edges are arranged as a shear, and the shaft is of the same size throughout, an important factor in the control of hemorrhage. The tip of the instrument is introduced through the ventricle into the auricle; the blades rest above and below the shelf of sclerosed valve, and as the handle is telescoped the blades approximate and excise a segment of the valve.

This instrument proved efficient for the desired task when used on the most thickened and calcified types of mitral valves available in the pathologic department of the Harvard Medical School. A method was devised for its use in animals, and in spite of the size of the instrument it proved but little more injurious to the action of the dog's heart than the small knives.

It became a standard procedure to expose the heart by subperiosteal resection of the left fifth rib, to place a suture in the apex for handling the heart, to place two mattress sutures parallel to each other toward the base of the left ventricle, and to cross these sutures. A small incision was then made between the sutures, and the blunt point of the cardiovalvulotome forced into the ventricle. The mattress sutures should be kept a little taut to prevent leakage about the instrument. This instrument and a similar technic were used in the next two human cases.

We are, however, a long way from the goal of devising a relatively safe and efficient operation for the resection of a segment of a stenosed mitral valve. Our experience in both the experimental work and clinical cases leads us to feel that the operation per se is one that can be borne even by obviously sick patients. The instrument devised can section the most fibrous and calcareous valve. A single task remains—and on this success or failure will depend—*the accurate placement of the instrument against the valve.* How can we orientate ourselves as to the position of the instrument when it is in the heart? Von Haecker [9] and Carrel and Tuffier [10] attempted visualization of the procedure by shutting off the entire circulation during the operation, opening the heart, cutting the

8. Beck, C. S., and Cutler, E. C.: A Cardiovalvulotome, J. Exper. Med. **40**:375-380 (Sept.) 1924.

9. Von Haecker, Rudolph: Experimentelle Studien zur Pathologie und Chirurgie des Herzens, Arch. f. klin. Chir. **84**:1035-1099, 1907.

10. Carrel, A., and Tuffier, T.: Etude Anatomopathologique et Experimentale sur la Chirurgie des Orifices du Cœur, Presse méd. **22**:173-177, 1914.

valves, and closing the incision. One can actually do this, but the time permitted in the successful experiments was so short that one could not contemplate such a procedure on man, in spite of the fact that in man a somewhat longer period of anoxemia would probably be tolerated, as indicated by the results obtained in the suture of wounds of the heart in certain of which, as Rehn [11] and Sauerbruch [12] advised, such a maneuver was necessary.

Lawrence Rhea and I. C. Walker attempted to improve on this in 1913 by devising an instrument, similar to a cystoscope and carrying both a light and a knife, which could be introduced into the heart and used both to see and to cut. They did not publish their results because of a failure to have any surviving animals. When we began our work in the laboratories at Harvard, we inherited this instrument and attempted to use it. We did not feel, however, that any appreciable vision was afforded in the opaque medium of blood. When Allen and Graham [13] published their interesting results with a more perfect instrument, we returned to a consideration of the idea of visualization by means of a system of lenses. Their instrument demonstrated a definite reason why the type of instrument devised by Rhea and Walker was unsatisfactory. In the latter the lens was inset, whereas, as Allen and Graham pointed out the lens must be at the tip, projecting, so that it can come into immediate contact with the tissue to be observed. An imperfect degree of vision can be obtained in the heart and we have been trying to perfect an instrument that includes the powerful cutting principle of the cardiovalvulotome with the accession of vision.

This instrument we call the cardioscopic valvulotome (Fig. 2). The general plan of the instrument remains the same, except that the distal portion is a planoconvex lens and that a right angle offset from the handle removes the eyepiece to a safe distance from the sterile field of operation. It has been used in experiments on dogs with success, and when the latest model with some improvements arrives we shall go ahead with the two cases that have been waiting for operation. Our inability to reach the stenotic orifice in our last human case made us feel that we should not attempt further cases until some such improvement was at hand.

Should this instrument and our method of attack prove satisfactory, there will still remain a question dealing with physiology rather than

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11. Rehn: Zur Chirurgie des Herzens und des Herzbeutels, Zentralbl. f. Chir. **34**:42, 1907.

12. Sauerbruch, F.: Die Verwendbarkeit des Unterdruckrerfahrens bei des Herzchirurgie, Verhandl. d. deutsch. Gesellsch. f. Chir. **36**:245-253, 1907.

13. Allen, D. S., and Graham, E. A.: Intracardiac Surgery—A New Method, J. A. M. A. **79**:1028-1030 (Sept. 23) 1922.

surgery; that is, how much of a correction should be made? We know from our experimental work that too great a deficiency is as serious as too great a stenosis. Practically, it would be difficult to create a marked insufficiency in the face of the typical pathologic lesion of mitral stenosis. However, this is a question that experience alone can answer since we have never been able to reproduce a comparative chronic valvular disease in animals. We must, therefore, always continue to err on the side of removing a segment too small rather than too large.

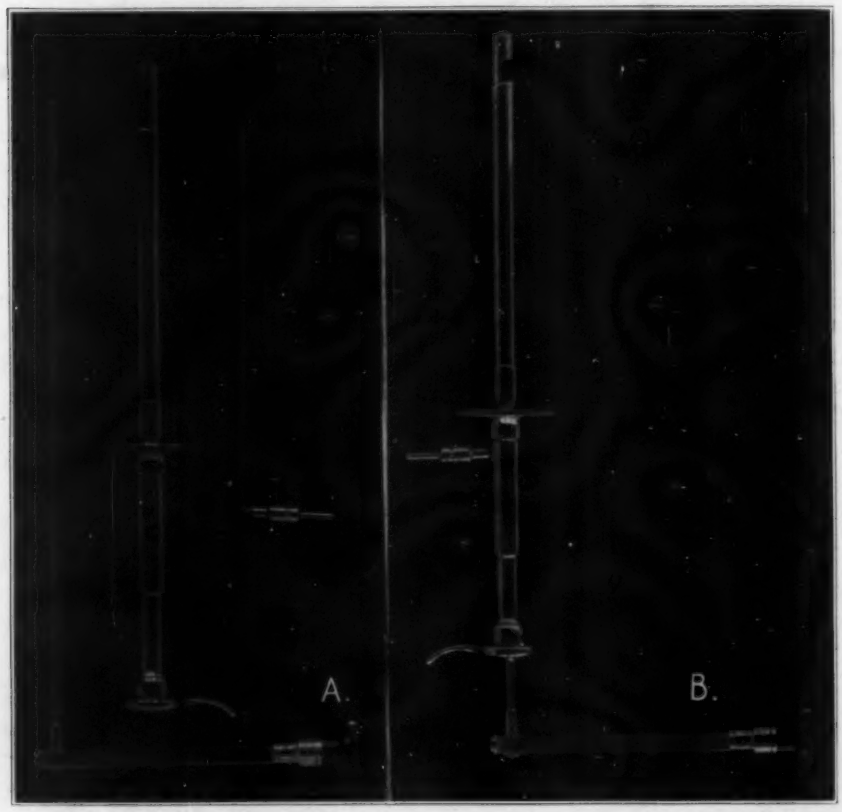

Fig. 2.—Cardioscopic valvulotome: *A*, component parts; *B*, instrument assembled.

OPERATIVE PROCEDURE IN MAN

We have elected a midline incision for two reasons: (1) to avoid pneumothorax, with its deleterious effect on an already inadequate pulmonary circulation; (2) because this incision is the only one that affords full exposure of all portions of the heart. We have adopted the Duval-Barasty [14] median thoraco-abdominal pericardiotomy as the most advan-

14. Duval, P., and Barasty, P.: De la Pericardotomie Thoraco-abdominale Mediane (Chirurgie du Cœur et des Grands Vasseauz de la Base), Presse méd. **26**:437-439 (Aug. 29) 1918.

tageous method of approach. The incision is long, but it is in the midline anteriorly and entails a minimum of trauma to nerves and blood vessels.

The incision reaches from the second rib to the midepigastrium. It is carried to the sternum and through the linea alba. The ensiform is excised; the sternum is split with a saw to the second interspace and there cut transversely. The split halves of the sternum are opened out, the pleurae dissected away laterally, the pericardium opened anteriorly, and the diaphragm and inferior pericardium split 2 or 3 inches (5 or 7.6 cm.) toward the crus. This gives an excellent exposure of the heart. By placing a traction suture in the apex, the heart can be steadied throughout the operative procedure. Parallel mattress sutures are placed in the wall of the left ventricle, crossed, the myocardium incised, and the cardiovalvulotome inserted. One or two Lembert sutures suffice to close the opening in the muscle after the instrument is withdrawn, the mattress sutures being pulled against each other and preventing all bleeding until this is accomplished (Fig. 3).

HUMAN CASES

We have had the opportunity of operating in five cases. In each case the typical physical signs of mitral stenosis were present. To each patient was explained the risk involved, and in the first case, the family were told that no similar operation had ever been performed. The patients accepted the risk as they had had disability long enough to realize that what their physicians told them about a life of restricted nature in the future was true. There is not the time to give a detailed report of the cases. Patient 1, a girl of 11 years, bedridden and orthopneic, suffered from attacks of such alarming hemoptysis that she was expected to die daily. Patient 2, a woman of 35, had been in bed off and on for three years with dyspnea, edema and fibrillation. Patient 3, a man of 26, was confined to his room with dyspnea and precordial pain. Patient 4, a girl of 19, and Patient 5, a girl of 21, were clerks who found that they would shortly be unable to continue an active life.

Patient 1 is living and apparently improved today, two years after operation. Signs of mitral stenosis are still present, but the patient has gained 10 pounds (4.5 kg.), hemoptysis has not recurred, and her general condition is undoubtedly improved. The other patients died, ten hours, twenty hours, seven days and three days, respectively, after operation. In the first three cases the small knife was used, in the last two cases the cardiovalvulotome. Case 3 was complicated by an adherent pericardium, and Case 5 by a beginning tricuspid stenosis. Death was due to myocardial failure in Case 2, to heart "tamponade" from acute

pericardial effusion in Case 3, and to pulmonary congestion and pneumonia in Cases 4 and 5.

From each case a great deal has been learned that will help in succeeding cases. We learned first that the small knife was insufficient for the task to be performed. The next instrument developed, the cardiovalvulotome, is efficient, but we still lacked clear orientation and

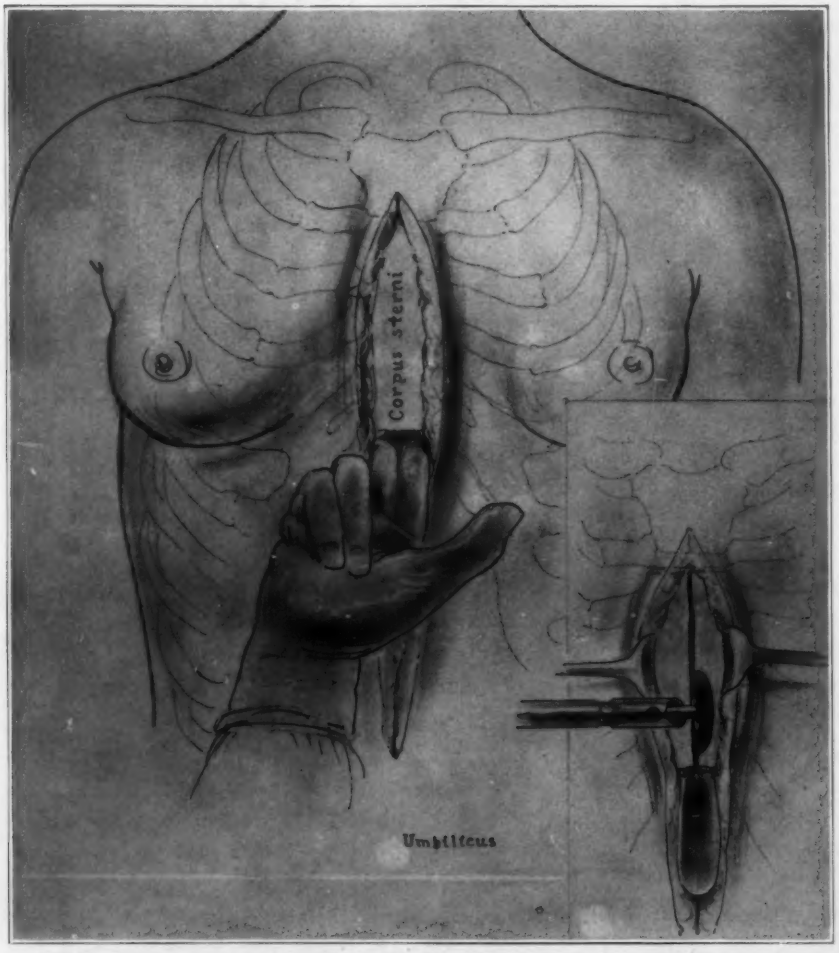

Fig. 3.—Skin incision and splitting of sternum.

ability to enter the stenosed orifice easily and surely. It is our hope that the addition of a lens and a light to this instrument will afford sufficient vision to allow accurate placement of the cutting edges against the diseased valve when the instrument is in the heart.

From a consideration of the four fatalities, we feel that we have also benefited. Patient 2 gave preoperative evidence of advanced myocardial disease (fibrillation had been present for several years and there was dependent edema). Such a patient would not again be accepted for operation. In Case 3 an unsuspected adherent pericardium was encountered, and we should have been satisfied with treating this

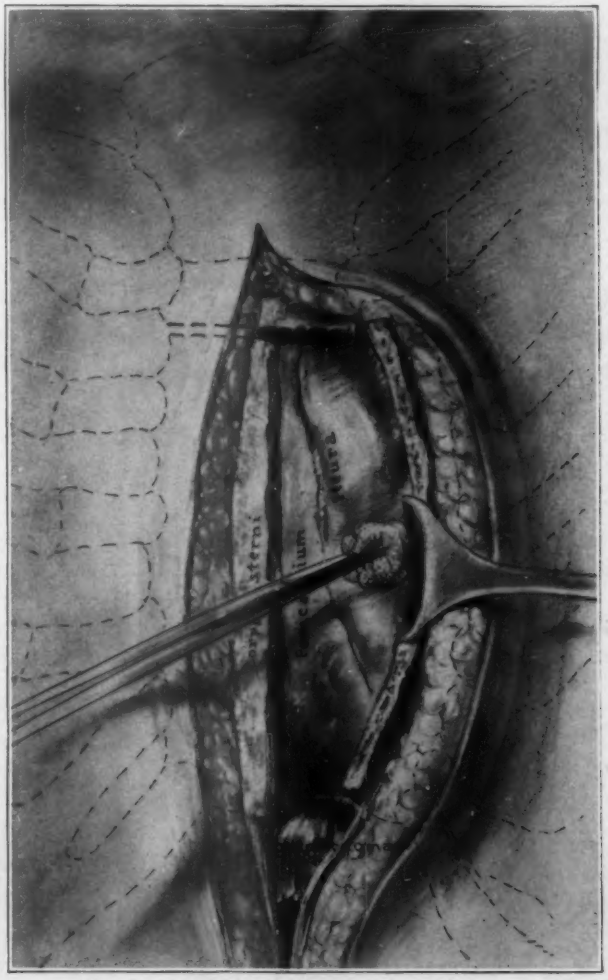

Fig. 4.—Sternum, split longitudinally and transversely; dissection of pleura.

condition only at the first operation. Moreover, we should either have drained externally or left unsutured the pericardium following its lysis from the heart. In Case 4 the patient had suffered from unexplained attacks of fever repeatedly in the months preceding the operation. A hidden pulmonary infection may have been a factor in the development

of the pneumonia, which was fatal one week after operation. Afebrile cases should be selected. In Case 5 there had been similar febrile attacks, thought before operation to be due to pulmonary thrombosis and infarction. Again we should have been warned away. These experiences, however, had to be learned for the first time; there were no previous ideas to guide us. If we can profit fully from these mistakes, we should do better in the future.

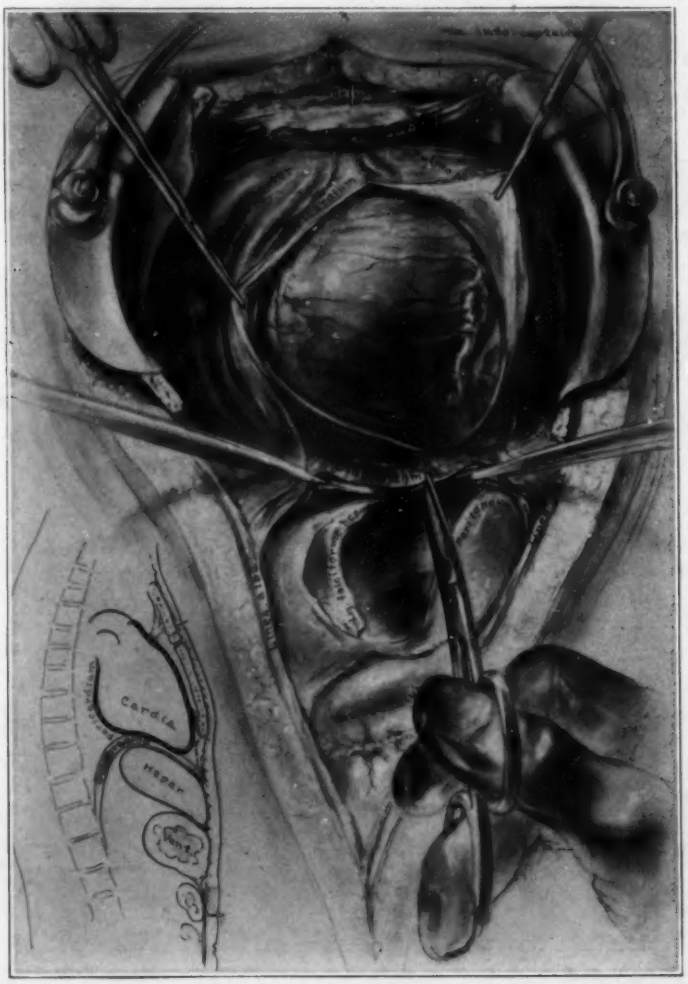

Fig. 5.—Diaphragm being split to afford better exposure of heart.

SUMMARY

We feel that the proposal that certain cases of mitral stenosis may be relieved by surgery has not been contradicted by our experiences. A mortality of 80 per cent. is alarming, but if one wishes to use this as

a criterion, it should be compared with figures obtained in the early surgery of other parts of the body. May we recall the early mortality percentages in gastric surgery reported by W. W. Keen [15] in his Cartwright Lectures of 1898? Of the first twenty-eight gastrotomies (1875), all the patients died. As late as 1896 the mortality for all cases of

Fig. 6.—Instrument inserted into ventricle with apex and control sutures in place.

pylorectomy was 72.7 per cent. In relation to brain surgery, may I remind you that Cushing [16] has stated that his first ten patients with brain tumor were all either made worse or succumbed.

15. Keen, W. W.: The Surgery of the Stomach, New York M. J. **67**:629-639; 701-711; 773-781; 809-819, 1898.

16. Cushing: In a discussion of the original presentation of much of this work, before the Harvard Medical Society, April 8, 1924.

This is indeed poor consolation, but until the proposal itself is proved to rest on faulty grounds, we feel further attempts should be made. Meanwhile, laboratory investigations are being continued. Every effort is being made to perfect the instrument so that better orientation within the heart may be had, and problems suggested during the trying periods of the care of these patients must be answered.

There is some consolation in the facts that there were no deaths on the operating table, and that one of our patients seems somewhat improved.

DISCUSSION

DR. DUFF S. ALLEN, St. Louis: This is a bold piece of surgery. To our knowledge that the heart will tolerate various surgical procedures, Dr. Cutler has added the fact that the heart with mitral stenosis may also tolerate incision into its chambers.

There are three important questions to be considered in the development of any surgical procedure. The first is, Should it be done? The second is, Can it be done? And the third is, How is the best method to carry out the operation? The question of whether or not one *should* operate on a stenosed heart valve is far from being settled. Up to the present time we have only two reported cases in which the patients have survived such an operation. The first attempt to widen a heart valve, the aortic, with survival of the patient was made by Tuffier of Paris in 1912. The second attempt to widen the stenosed heart valve, the mitral, with survival of the patient is the one which has been reported here today by Dr. Cutler. Five other cases have been unsuccessfully attempted. These seven cases of stenosis do not prove or disprove the question of whether such procedures should be attempted. The rationale of such operations depends largely on the proper selection of cases. We have drawn a few tentative conclusions from our study of cases and hearts with mitral stenosis. I wish to outline briefly the ideal case for such an operation.

First and most important, the case should be one of progressive early stenosis. The symptoms of mitral stenosis should not have been present more than a few months. The main reasons for this conclusion are found in a study of the process of the formation of a mitral stenosis. The mitral valve is really one structure. The "leaflets" are in reality widened portions of this structure. It is not necessary for one "leaflet" to grow to the other—by a kissing process—in order that a stenosis should be formed. In fact, we doubt that this kissing process ever occurs. Instead, fibrous tissue is laid down in the entire valve and the stenosis takes place by a slow sphincteric action as the result of contracture of the connective tissue in the valve. If the sphincteric band were cut during the contracting stage, the ends of the band would be gradually pulled apart to relieve the stenosis, perhaps to form a regurgitation instead. This could not take place as readily if the valve had become calcified.

Another reason for early intervention is that, owing to the presence of the stenosis, changes take place in the myocardium. These changes, a "myocarditis," are especially marked in the left auricle and the right heart and, unusually, less marked in the left ventricle. Still another reason for early intervention is that changes in the lungs occur as the stenosis progresses. For these reasons, we believe that the ideal case of mitral stenosis is one which is still progressing and which has a good myocardium with a good vital capacity and high oxygen unsaturation, i. e., little or no cyanosis.

METHOD

The method of carrying out the operation for the relief of mitral stenosis is of first moment. Whether or not such operations can be done is a question of greatest interest, but of far greater consequence is the method for carrying out such procedures. Let me make that statement clear by an analogy: One can remove a lung with survival of the patient, but the method by which the lung is removed is the important thing. If the lung is cut away, for example, at a one stage operation, the procedure is a spectacular one but a majority of the patients will die of a mediastinitis. Similarly, we believe that the choice of the procedure of cutting the mitral valve will play a great part in the mortality and, therefore, the final determination of the feasibility of such operations. The method of carrying out such operations is therefore important.

Two operative procedures for the relief of mitral stenosis have been advocated and practiced. They differ widely in important details. The blind transventricular procedure devised by Schepelman in 1912 and used by Cutler in his reported cases has been described by others.

In 1920 we had tried, experimentally, the blind transventricular approach to the mitral valve and had discarded it as impracticable because it contemplated an approach through the all important left ventricle and contained a marked element of uncertainty. We still hold this view of the blind transventricular approach to the mitral valve. Two years ago we presented before this society a method for operating on the mitral valve under direct vision and by a transauricular approach to the mitral valve.

The visual transauricular approach differs from the blind transventricular approach in four main features: (1) The approach to the mitral valve is through the left auricular appendage; (2) no adhesive pericarditis of the ventricles follows the operation; (3) ventricular fibrillation never occurs; (4) there is no injury to the left ventricle on which the circulation and hence the life of the patient depends. In the transventricular approach (1) an adhesive pericarditis of the ventricles has always followed the operation; (2) there is a serious disturbance in rhythm of the heart, sometimes death from fibrillation; (3) the pressure may be changed in the left auricular appendage with the possibility of dislodging thrombi within it and without means of preventing this serious complication, and (4) there is always an injury to the most necessary chamber of the heart, namely, the left ventricle.

Let us consider the practical applications of these two operative methods of the treatment of mitral stenosis.

In August, 1923, we made our first attempt to operate on the stenotic mitral valve of a human heart by use of the cardioscope with its manometer and the transauricular approach to the valve. The case was one of a long standing stenosis in which the patient had had hemoptysis and shortness of breath sufficient to keep her confined to bed for months. At the time of operation, however, she seemed to be a fair risk. She could walk about the hospital wards with but little dyspnea; there was definite cyanosis of the lips and the fingers. Her fingers and hands were the small tapering type indicating a stenosis acquired early in life. She was 31 years of age at the time of the operation; her vital capacity varied from 1,000 to 2,400 c.c. The operation was done in three stages. At the first operation the second, third and fourth costal cartilages were removed. The second operation was abandoned after exposure of the pericardium because of respiratory difficulty and the rapid pulse of the patient. During the third operation, which was done under nitrous oxid-oxygen anesthesia, the respirations were never below 60 a minute even before the operative procedure was started. The incision was made beginning at the middle of the left clavicle, to the

suprasternal notch, then down to the fourth interspace and outward to the midclavicular line. The soft tissues were reflected back and the second, third and fourth costal cartilages removed. The anterior mediastinum was entered, the left pleura stripped away from the pericardium, and the pericardium opened at the left auricular appendage. The left auricle was greatly distended and could not be seen to contract although the electrocardiograph showed a tall P, or auricular, wave. The left auricular appendage was found to be greatly distended, its walls thickened. It was dumb-bell shaped.

When the auricular appendage was grasped and clamped, there was no visible change in the rhythm of the heart. The rate of the heart was very rapid, around 200.

The anesthetist reported the patient's condition as "bad," but since our manipulation of the heart caused no visible disturbance in rhythm the operation was not abandoned. The base of the appendage was clamped, the tip incised. It contained no clots. Difficulty was encountered in tying the scope into the appendage owing to its abnormal shape. The respirations and the pulse of the patient continued to grow more alarming. The respirations stopped; the heart rate became very rapid. Four cubic centimeters of 1:1,000 epinephrin-hydrochlorid was injected into the left auricle. The pulse became stronger. We tied off the auricular appendage but the patient expired before we could close the wound. We felt then and still believe that death was not due to manipulation of the heart since it had no effect on the rhythm. We did not see the ventricle throughout the operation.

We consider a case of mitral stenosis of long standing to be unsuitable for operation on the mitral valve.

I do not wish to comment on Dr. Cutler's series of cases except to say that by the blind transventricular method it seems to me that he has failed to relieve the stenosis properly.

In his first case, there was no change in the diastolic murmur. This, I believe, is reason to doubt that the stenotic valve has been incised in spite of the improvement, which may be an intermission or due to decompression of the large heart.

In the second case of this series, there also were two small incisions in the valve. Was the stenosis properly relieved?

In the third case of his series, at necropsy a 3 mm. incision was found at either side of the stenotic orifice and the chordae tendineae of the anterior leaflet had been cut. Were the incisions sufficient to relieve the stenosis? Was the operation within the heart the one he had intended to do?

In the fourth case of the series, a segment of the calcified valve was removed. Was the segment too small or too large? The patient died. Clinically, a pneumonia followed the operation, but the pathologic examination of the lungs showed instead a pulmonary edema. In our experiments such a pulmonary edema follows after we have created too large a defect in the mitral valve. It is logical to infer, therefore, that the segment of valve removed by the punch was too large.

Uncertainty is one of the inherent attributes to the blind transventricular methods. We do not attach as much significance to the mortality figures in this series of cases as we do to the failure to enlarge the stenotic opening properly. Experimenters working with animals have always experienced failures to incise or excise portions of the mitral valve by the blind methods. Can we expect to do better in the human heart? No. An insufficient incision or too great an incision of the valves are the same in that both fail to accomplish the object of the operation, the proper enlargement and relief from the stenosis.

By use of the cardioscope and its attached manometer one can avoid this uncertainty both as to the structure that is being cut, i. e., the mitral valve, and also as to the size of the incision or the relief of the stenosis.

The cardioscope is inserted into the left auricle. A manometer has been built into the side of the cardioscope; the blood pressure within the left auricle may therefore be measured during the operation. With a stenosis of the mitral valve, the mean blood pressure within the left auricle is high and the pulse pressure is small; with a mitral regurgitation the mean pressure in the left auricle is lower and the pulse pressure is larger; with the normal mitral valve the mean pressure is still lower but the pulse pressure is smaller than in a regurgitation.

If therefore, one takes the mean blood pressure in the left auricle behind a stenotic valve and by incision should change the stenosis into a regurgitation or a normal condition, the mean pressure should fall.

Our intention is to begin with too small an incision into the stenotic mitral valve, take our mean pressure reading directly from the simple, straight glass tube manometer, cut again, read again and continue thus until we have enlarged the stenotic orifice just enough and not too much. This is important.

Cutler, Levine and Beck, in giving the reasons for the use of the blind transventricular methods, give instead reasons against the visual transauricular method. Their principal reason against the transauricular approach, as described by Graham and myself, was that the left auricle of the human heart with mitral stenosis was too weak to tolerate operative procedures. Unfortunately, they did not test the strength of such left auricles. We did not think that they were correct in their assumption, so we took warm hearts at necropsy and ran water into them. We found that the thin left auricle would support a column of water 23 feet in height without rupturing the auricle. It is a strong fibrous chamber of the heart. In the condition of mitral stenosis in which the left auricle is always hypertrophied, one would expect even greater strength in the wall of the left auricle. Twenty-three feet of water is equal to a blood pressure of more than 500 mm. of mercury. This is fifty or a hundred times the normal pressure within the left auricle and much higher than could ever exist inside the living left auricle under any condition.

We feel that the left auricle is not only the logical avenue of approach to the mitral valve, but also that it is strong enough to permit its use. By the use of the cardioscope and its manometer, one is enabled to carry out the operation as a well controlled procedure.

Dr. Howard Lilienthal, New York: In Dr. Cutler's future operations in which the sternum is to be divided, I would suggest the use of an instrument known as Schumacher's sternum shears. The blade of this instrument is 1½ inches (3.7 cm.) long, or even more, and passes easily through the bone without shock and without the traumatism that is encountered in sawing. I have employed this instrument to my satisfaction.

Dr. Willy Meyer, New York: Would it not be wise always to be ready for differential pressure?

Dr. Elliot C. Cutler, Cleveland: It is obvious that there exists some difference of opinion concerning the technical performance of the operation. The method employed for cutting the stenosed mitral valve, however, is not the most important consideration of this work. The hypothesis that underlies it is of greater importance because on the soundness of it depends further progress.

One of the factors that works against the greatest advancement in any experimental field is that the subject is discontinued before the work is completed. We are prone to spend a year or so on a problem, then to drop it for something

else. The real gifts to medicine, I believe, come from prolonged investigation of one subject rather than contributions to varied subjects. I am reminded of the work of Dr. F. B. Mallory on copper poisoning. When I worked in his laboratory ten years ago, his hobby was alcoholic cirrhosis of the liver. Twenty-three years were spent on the subject of hemochromatosis. Had it been dropped earlier such an important contribution would not have been made.

It is unfortunate that the fundamental idea on which this work of relieving mitral stenosis surgically is based has not been demonstrated experimentally. In animals a mitral stenosis comparable to that found in the human being has not been produced. The question, apparently, can be settled only by operation in human cases. Until it can be shown that the idea carries with it little or no hope for improvement, we should go ahead.

The patient that presents himself for operation is usually not the type that one would like. He comes only after years of deterioration, when he is convinced that otherwise there is no hope. If then we are to be confronted with this task of operating in cases of mitral stenosis, we must be practical in our application. We must select from the patients who are going to pieces those who have good cardiac muscle. We must have an instrument that can excise a segment from the toughest and most sclerotic valve.

The approach to the mitral valve, whether through the ventricle or through the auricle is probably not settled. The latter presupposes a transpleural approach to the heart. With the badly congested lungs that necessarily accompany mitral stenosis I have the greatest hesitancy to open the pleura. A further reason for the ventricular approach and the midsternal incision is that the latter provides an excellent exposure of the heart.

Without complete exposure of the heart I should hesitate to carry out such a critical operation. In one of our cases a rent was accidently made posteriorly in the left auricle. The bleeding was easily controlled. With the heart displaced to the right and slightly rotated, a pledget of cotton placed on the wound controlled the bleeding until a suture could be placed. The midsternal approach is not difficult and can be carried out in a few minutes.

The application of vision, as described by Allen and Graham, may be of great value to the operative method. I believe a system of lenses and prisms, providing the more or less imperfect degree of vision that they afford, should be incorporated in an instrument (cardiovalvulotome) * that can excise a segment from a tough and calcareous valve.

The approach through the ventricle does not seriously affect the cardiac action. Elsberg in 1907 was able to resect one-half the ventricle with recovery, and in our experiments on dogs the incision in the ventricle was well tolerated with two exceptions. In these cases death followed incision of the base of the anterior papillary muscle and demonstrated to us the advisability of making the incision as near the apex of the heart as possible. The human heart tolerates trauma well. Anyone who has sutured a stab wound of the heart knows this.

I hope that the instrument which we have devised, which adds to our cardiovalvulotome the principle of vision, will be used shortly at operation, and I hope that we will have more success.

The question Dr. Lilienthal brought up as to the use of shears is of interest to us. I used shears in the first two cases, but a shear when it cuts leaves an irregular edge. One of the difficulties in the postoperative course was pain, especially where the sternum was closed with wire. With a saw one can cut the sternum rapidly and get a smooth incision that is not painful subsequently.

As far as differential pressure is concerned, we have felt that to be an important point. We have used straight ether from the Connell machine through a nasopharyngeal tube which we could easily use under forced pressure if necessary. There already is a poor circulation and the lung is one of the most critical points in the recovery of your patient.

RADIUM THERAPY IN CARCINOMA OF THE ESOPHAGUS

WILLIAM S. STONE, M.D.
NEW YORK

My experience is limited to the study of cancer of the esophagus and cardia and the results of radium treatment during the last eight years. This was begun in conjunction with the work of Dr. H. H. Janeway, whose experience in the treatment of cancer of the esophagus with radium was extensive. The practical results, however, were disappointing. Dr. Janeway used various methods which I had the chance to observe.

Perforation of the esophagus, either as a result of the use of radium or from the extent of the disease, was not infrequent and its clinical picture was most typical. I emphasize the dangers of radium treatment to be avoided by those who are taking up this work.

One patient Dr. Janeway reported as cured, but there was a little doubt in regard to the diagnosis. In other words, at the Memorial Hospital there has not been a single case that can be said to have been cured by radium. There were a few cases I think in which some palliation was obtained.

Recently Dr. Douglas Quick by using a new technic has been able to obtain a considerable degree of palliation for more than a year in two cases. This was by the use of small quantities of radium emanation, 2 or 3 millicuries, I believe, in a heavily filtered capsule of a millimeter of platinum so as to get only the gamma radiation. These were left in the esophageal tube for about two days. That technic has yielded the best result so far.

This work, however, has not all been for nothing. There is one important thing we have learned; that is, that the operation of gastrostomy is much more of an important palliative procedure than most men think, and it should be done earlier than either the patient or the majority of the physicians think necessary, just the same as a colostomy is the palliative treatment of cancer of the rectum. It is known how often after gastrostomy the patient is able to swallow. There is a perfectly clear reason for such a result. As in cancer of the rectum, after the stoppage of the irritation from the foods and fluids the tumor diminishes in size and the patients are able to swallow. One often sees a tumor of the rectum diminish in size one-half after a colotomy is performed.

The desirability of urging patients to submit to a gastrostomy earlier than is ordinarily considered necessary is the chief point I

would make. The other important thing it seems to me in approaching this problem is to consider carefully the anatomy of the tumor, and the normal anatomy of the esophagus. It is extremely rare to find an early case. It seems that just as soon as the growth is formed, the wall of the esophagus is so delicate and thin, that it extends into that loose cellular tissue surrounding the esophageal wall without apparently extending much as an ulceration of the mucosa. The growth will proceed up and down beneath the wall of the esophagus, and reach extensive proportions without one's being able to detect it by any method of examination.

That seems to be the chief obstacle to success, because it seems that if one had a small ulcerating growth that was absolutely limited to the wall of the esophagus, it would be possible to cure it by radium.

I have had no experience with the surgery of this disease, but as I take it, the technic is difficult; it is a dangerous operation, and the same problem is presented in surgery as is presented in radium. The difficulty is in knowing its extent, and I think the chief point to be drawn from all this work is, first, for men taking up radium treatment to go over carefully the work that has already been done, particularly, I think that by Dr. Janeway, because he really was a pioneer, and to accept that work and avoid the dangers of perforation, which does certainly occur when the lesion is overdosed.

The second lesson is the necessity and desirability of performing gastrostomy sooner than the patient and the majority of surgeons and physicians deem it necessary.

It may be that a combination of surgery and radium will produce better results. The surgeon, by exposing the tumor, may allow the radiologist to apply the radium more accurately.

SURGICAL TREATMENT OF CARCINOMA OF THE ESOPHAGUS

FRANZ TOREK, M.D.
NEW YORK

At the last annual meeting of the American Association for Thoracic Surgery the most important procedures of operating on carcinoma of the esophagus were discussed. We took up the two great chapters of transpleural and mediastinal approach. For tumors low down near the cardia a method of preliminary collapse of the chest and lung also was described and a method of transplanting the diaphragm upward above the tumor and operating abdominally.

As regards operative results, four of our members were able to report recoveries, and one related the case of a patient who lived thirty-nine days after operation. Of the patients with carcinoma of the thoracic esophagus reported at that meeting two were presented at the joint meeting, two months ago, of the New York Surgical Society and the Philadelphia Academy of Surgery in New York. One of these had been operated on by Dr. Eggers, the other by myself. To those present at that joint meeting it was evident that the interest in operative attack in these cases had become much more intense. Of these two patients Dr. Eggers' patient has lived more than a year and is in good health. My patient lived more than twelve years; she died a short time ago of pneumonia at the age of 79 after having been in good health up to three days before death. In operations for carcinoma of the esophagus at the cardia we have reports of successes by Voelcker, Kuemmel, Zaijer and Hedblom, not mentioning the number of patients who have lived a couple of weeks after operation and died of some accidental complication.

In view of these cases the possibility of a cure of carcinoma of the esophagus by surgical operation is now well established. We no longer regard an isolated cured patient as a freak case that had the good luck to pull through. Those times are past; the operative treatment of carcinoma of the esophagus is on a sounder footing at present than it was a decade or so ago. It behooves us now to consider the cause of the high death rate and the way in which this should be changed.

It cannot be stated too often that these patients fail to receive surgical treatment early enough. The failure of the patient to submit to radical removal of the new growth at an early stage of the ailment is due in part to the nature of the case, in part to neglect by the patient himself, and in part to the physician's uncertainty what advice to give. Any of these three factors may be responsible for the postponement of surgical intervention and for the advanced state of the disease when

the thoracic surgeon sees the patient. As a rule all three factors have been at work in the order mentioned.

Over the first of these, the nature of the case, we naturally have no control. Nevertheless, it is essential that we appreciate the existence of this factor, as we may possibly, through its realization, be enabled to suspect the presence of the disease at an earlier date. Picture to yourselves a malignant lesion of small size, affecting only the mucous surface of the esophagus, and consider what evidence it might give of its presence. It will surely not manifest itself by causing obstruction at the site of the lesion. Any one who has given some attention to the esophagus, especially with the aid of roentgen-ray examinations, knows that it is a highly distensible organ, and although the portion of the circumference that harbors the new growth may be rigid, the remaining, uninvolved portion will be capable of expanding to such a degree as to obscure entirely the presence of any shortcoming. What actually may happen is either that the presence of so small a lesion may cause a reflex spasm of the cardia, owing to nerve irritation at the ulcer, or the ulcer may bleed. Cardiospasm as a result of an ulcerative lesion in the esophagus may arise through occurrences in the nervous mechanism similar to those in which a gastric ulcer causes pylorospasm. The former would not be so likely to occur as the latter, because the irritation of the esophageal lesion is not so prolonged as that of the gastric ulcer. If, however, signs of cardiospasm do occur in a patient formerly not afflicted with nervousness, there would arise an indication to investigate for the existence of an esophageal lesion. As regards the other possible occurrence mentioned, bleeding from the ulcer, it is almost certain that that would pass unnoticed as the blood would probably be propelled into the stomach. Only in case cardiospasm should simultaneously be present, the blood might be regurgitated and would then present an indication for further investigation.

So much for the possible signs in the early stages of the tumor. I am tempted to call these the signs of the first stage. They may be entirely absent, or if present, may be vague. As the growth encroaches further on the lumen of the esophagus, however, actual signs of an incipient, partial obstruction develop, which I should like to call signs of the second stage. Larger, less well chewed morsels of food are temporarily halted at the site of the lesion, and while they are thus delayed, the patient feels some kind of sensation in the region of the sternum or in the epigastrium which he describes either as a pain or a feeling of pressure, constriction, or other kind of discomfort. However as long as this is only temporary and the food finally goes down, the patient usually pays no particular attention to it, believing that there is nothing the matter except that he has to chew his food better; he omits from his diet certain articles he has found to be held up in the

esophagus. Here is where the patient often neglects himself and fails to consult a physician until some portion of his food or some particular kind of food absolutely refuses to pass down. This occurrence I characterize as the third stage. At this stage the diagnosis is apt to be comparatively easy and is established with the aid of bulbous bougies, roentgenograms and, if necessary, esophagoscopy. It is important for the physician to appreciate that at this time the disease is no longer in an early stage. He should understand that, to bring about this degree of obstruction, it must have existed for a fairly long time, and that it needs prompt attention. He should also know, from his studies of carcinoma generally, that any procedure by which only a portion of the new growth is destroyed not only fails to lead to a cure of the disease but may even stimulate it to further and more rapid extension. He should appreciate that a cure of the disease requires the removal or destruction of the whole new growth together with a certain margin of healthy tissue beyond its limits.

Now, to come to a conclusion what should be done, let us bear in mind the following facts: At the time when the diagnosis is made, and thus far this has been invariably in what I called the third stage, the lesion, which started from one small point on the surface of the mucous membrane, has almost, if not quite, encircled the lumen, taking a number of months to develop to that extent. But while it has extended transversely it has likewise spread out in every other direction, upward, downward and, what is most important, into the depth. By this time the involvement has extended well into the muscular coat. I have never seen a case of carcinoma of the esophagus in which the muscular coat was not involved, although I have not given up hope that I may some time be so fortunate. What does that signify to us in reference to the selection of therapeutic measures? It means that a destruction of the full thickness of the esophagus is imperative. In other words, the removal of the diseased part, in order to be effective, must destroy the continuity of the tube. Any method of attacking the disease from within the lumen, whether it be by radium or any other method of destruction, which avoids going through the full thickness of the esophagus, falls short of the evident requirements of a thorough removal. On the other hand, if the destruction, by the use of radium, is extensive enough to penetrate the entire thickness of the esophagus, fatal mediastinitis results, as has frequently been observed, not usually after the first application of radium but after one of the subsequent ones.

Another requisite for the radical removal of a malignant growth is a thorough exposure. Through the esophagoscope this would be possible only in an ideally favorable case, the kind I classified above as belonging to the first stage; but even in such a hypothetical case the

esophagoscope would reveal only the extent to which the mucous membrane is involved, whereas the estimation of the depth to which the disease extends remains more or less guess work.

Viewed from this standpoint the rational procedure in carcinoma of the esophagus is its removal by surgical operation, and although the statistics are not as yet satisfactory, they are nevertheless better than those attained by any other method. They would be vastly better if physicians would refer the patients to the surgeon just as soon as the diagnosis is made, for even that time is late enough, as has been outlined here. Instead, however, the patient is often treated for months in a variety of ways before being sent to a surgeon. The history of a recent case will serve as an example: In the first part of his illness, for a period lasting about six months, the patient presented at first the rather vague symptoms described in the early part of this article as those of the second stage, to which he paid little attention, and later the fairly well defined symptoms of incomplete obstruction. Then he sought medical advice. The diagnosis of gastritis was made, and he was treated accordingly for two months, of course without improvement. Three and one-half months before I saw him absolute obstruction set in, necessitating a gastrostomy. Then an esophagoscopy was done and a portion of the new growth removed for examination, which proved it to be carcinoma. Then radium was applied in the retrograde manner described by Yankauer. This failed to reopen the lumen and he was subjected to six deep roentgen-ray treatments, also without the slightest effect on his ability to swallow. Finally, the conclusion was reached that these measures had had a fair trial and were of no avail, and the patient was referred to me for operation. Exploratory thoracotomy proved the tumor to be inoperable. The wall of the aorta was already involved, and retroperitoneal nodes could be felt through the diaphragm.

It will surely be agreed that this sort of case, and it is characteristic of the majority, is not the kind of material to furnish the best results for surgical treatment. The correct diagnosis could have been made eight months before he was referred to me. To judge the statistical results obtained under such handicaps is hardly fair. Yet, in spite of all our preachments, the prevalent standpoint among physicians is still that of reserving the advice of surgical treatment for carcinoma of the esophagus as a last resort, after everything else has failed.

To offer chances of a favorable outcome by resection the two most important conditions are, first, that the tumor has not involved tissues outside of the esophagus and, second, that the patient's general health is fairly good. Let us have the cases of carcinoma of the esophagus for operation as early as possible, and we will show much better results than are now obtained.

WHY DOES NOT THE THORACIC SURGEON CURE CANCER OF THE ESOPHAGUS?

CHEVALIER JACKSON, M.D.
PHILADELPHIA

Cancer of the esophagus is not a rare disease. McCrae in 5,480 necropsies found twenty-nine cases of cancer of the esophagus. It ranks high in the general cancer incidence; only uterine, mammary and gastric cancer exceed it in frequency. It is not an aggressive type of malignancy; on the contrary, it is a mild, slow and for a long time purely local process. These ideal conditions for surgical cure render important the query that is the title of this article.

The answer is not far to seek. If we open any textbook on medicine and surgery we find the answer in the means employed for the diagnosis of esophageal disease. These means are the traditions perpetuated in the textbooks from a bygone age when all diagnoses were inferential, not objective.

DIAGNOSTIC METHODS IN THE TEXTBOOKS

The diagnostic methods given, first or exclusively, in the textbooks are faulty for the following reasons:

1. They are always negative early. How many cancers of the cervix would be cured if all the diagnostic means were always negative early?

2. They are all inferential, not objective. How many cancers of the cervix would be cured if the diagnostic means advocated were all inferential?

3. Not only are they all negative early but they also are inconclusive, even late.

4. Collectively they do not give the early and positive diagnosis essential for the cure of cancer anywhere.

5. They all depend on obstruction. In a loose resilient redundant tube like the esophagus it requires a well advanced cancer to cause a marked degree of obstruction. Sloughing cancers often do not cause obstruction till late; a few are never obstructive.

THE HISTORY OF THE CASE

In the textbooks and the journal articles great diagnostic importance is attached to the history of the case. It is an inferential method that is not only always negative early but is diagnostically useless and often absolutely misleading at any stage. It is not uncommon to have a

patient come to the Bronchoscopic Clinic with the history of never having had trouble with swallowing until a few weeks before. With this history the inference would be negative because cancer cannot develop in a few weeks. Other cases have come with a history of dysphagia for as long as twenty years. Inference would exclude cancer, yet we find histologically proved cancer in such cases. In nearly all cases of cancer of the esophagus there is a history of intermittent dysphagia with intervals, often of months, in which there is no difficulty whatever in swallowing. Here, again, inference from the history of the case would mislead into the exclusion of cancer. There may be spasm in these cases superimposed on or secondary to the organic lesion; but in most of the cases lodgment of certain kinds of ill masticated food and inflammatory swelling are the causes. Be this as it may, the clinical fact remains that the history is diagnostically useless and misleading.

BLIND BOUGIENAGE

The textbooks attach great importance to the blind passage of a bougie. It is not an objective method but an inferential one. If it meets with no obstruction the inference is that there is no cancer, yet early cancer of the esophagus is not obstructive, and even late cancer of the sloughing type may be nonobstructive. If it stops the inference is that there is stenosis, and if the patient is of cancer age it is inferred that the stenosis is cancerous; yet a normal fold may arrest the passage of the bougie blindly passed. If the bougie comes back bloody the inference is that the blood is cancer blood; yet one can draw blood from normal mucosa with a bougie. If the bougie comes back foul the inferential error is compounded. There is nothing more foul than a septic mouth or diseased lymphoid tissue. Many times has the esophagoscopist been able to reassure a frightened patient on whom an erroneous diagnosis of cancer has been made with the bougie. This does not complete the case against the bougie. Trousseau said that all patients with esophageal stenosis sooner or later died of the bougie.

The bougie then is always negative early, always inferential and inconclusive at best, often fatal at the worst.

EARLY AND POSITIVE DIAGNOSIS ESSENTIAL

It is a platitude to say that an early diagnosis is necessary for the surgical cure of cancer anywhere. It is essential in cancer of the thoracic esophagus for the additional reason that the patient must be able to withstand a major operation. This imples that one must propose to a comparatively well man an operation he may not survive. Exploratory operation cannot be resorted to as unhesitatingly as in the abdomen. No surgeon cares to expose the thoracic esophagus and then find a so-

called "cardiospasm" or other benign condition. And there is absolutely no necessity for his being subjected to such chagrin. An early diagnosis of cancer can be made in the esophagus with the same degree of certainty as on the cervix if the textbooks and the profession will abandon methods of diagnosis that are not only always negative early, but inconclusive at any stage.

RELIABLE DIAGNOSTIC METHODS

There are only two ways in which the diagnosis of cancer of the esophagus can be made early and positively; namely,

1. Roentgen-ray examination.
2. Esophagoscopy.

Roentgen-Ray Diagnosis.—It is rare in our own experience that the results of the fluoroscopic and roentgenographic study by an experienced roentgenologist, with the best of modern equipment, is erroneous in diagnosing or excluding cancer of the esophagus. It is wise, however, to supplement by esophagoscopy the roentgen-ray study, which should be made first in all cases.

Esophagoscopy for Diagnosis.—When, thirty odd years ago, I first saw a cancer of the esophagus through the crude esophagoscope of the day and realized the earliness and certainty with which a diagnosis could be made, I called attention to the 100 per cent. mortality and hoped for better things. These things have not materialized, chiefly for two reasons:

1. Tradition has handed down from textbook to textbook the false teaching of inferential diagnosis of esophageal disease. If esophagoscopy is mentioned at all it is placed last on the list; hence is resorted to last instead of first.

2. When an esophagoscope has been used, only too often it has been without realization of the fact that esophagoscopy is a highly technical procedure. Any surgeon can learn to do esophagoscopy but he cannot do it safely without learning by instruction. Failing to realize this an esophagoscope has been sent for, pushed down by an uninstructed man who, though skilful in other work, had never before looked through, much less passed, an esophagoscope. Death has followed and esophagoscopy has been unjustly discredited. Many now well established methods in medicine and surgery have gone through this stage of ill advised use to be followed by safe and sane and proper use.

A properly trained esophagoscopist, if he has an opportunity, can make a diagnosis of an endo-esophageal cancer no larger than a cherry pit with the same certainty with which the gynecologist recognizes a cancer of the same size on the cervix. If histologic proof is required, as I think it should be for a transthoracic esophagotomy, a specimen

can be taken for biopsy. A specimen reported on as histologically cancerous has never in our experience been disproved by the progress of the case or otherwise. Specimens are sometimes inconclusive and call for the taking of another specimen. Sometimes it has seemed unwise to take a specimen, in which case a later esophagoscopy has found conditions warranting the procedure. It is chiefly in endo-esophageal cancer that esophagoscopic diagnosis is an early, certain and safe method. In periesophageal malignancy positive results are not obtainable so early; but periesophageal cancer is hopeless. It is in the cases of primarily endo-esophageal cancers that the thoracic surgeon will at no distant day obtain his cures.

With a view to obtaining data on the accuracy of esophagoscopic diagnosis *without* biopsy a questionnaire was sent out. To this there were received reports from seventy-eight esophagoscopists who had made the diagnosis of cancer of the esophagus in 1,269 cases. The esophagoscopic diagnosis was correct in 1,204 cases, 92 per cent. incorrect in 3 per cent., inconclusive in 5 per cent. There are few diagnostic methods that show a higher percentage of correctness. These figures do not include our own statistics.

SUMMARY

Notwithstanding the fact that cancer of the thoracic esophagus is a mild, slow and for a long time purely local process, the thoracic surgeon has made little progress in its cure because he never sees these cases in an early stage. The reasons why he never sees the cases early are these:

1. Every case of esophageal cancer is a medical case until it is too late for surgical cure, not only because of extension and metastases, but because the patient is a hopeless subject for any kind of major surgery.

2. The diagnostic means advocated, first or exclusively, in the textbooks are always negative early.

3. The history of the case is useless diagnostically, and often directly misleading. Cancer of the esophagus may exist in a patient giving a history of only a few days dysphagia. On the other hand, some patients give a history of twenty years of dysphagia. Inferential exclusion of cancer would be wrong in both instances. A history of intermittent stoppage of food with normal intervals is supposed to indicate spasm. Here inference is wrong again; intermittent dysphagia is present in all cases of cancer at some stage.

4. Blind bougienage is always negative early because it depends on obstruction. No cancer of the esophagus is ever thus obstructive early. It takes a large growth in a loose, resilient redundant tube like

the esophagus to cause obstruction. Sloughing cancer may not be obstructive even late. The bougie may be stopped by a normal fold or a nonmalignant stenosis; it may be bloody from contact with normal mucosa; it may be foul from septic lymphoid tissue in the pharynx. Bougienage is an inferential method, late and inconclusive at best, fatal at worst.

5. There are only two safe, certain and early methods, namely, the roentgen-ray examination and esophagoscopy.

6. What the thoracic surgeon needs to cure cancer of the esophagus is an early and absolutely positive diagnosis. This can be made in only one way; namely, with the esophagoscope. There is good reason for believing that when the day shall have arrived when every patient with supposed "globus hystericus" or with the slightest subjective abnormality in swallowing is promptly examined with the esophagoscope, the thoracic surgeon will show a good percentage of cures.

7. A cancer no larger than an orange seed can be diagnosed just as positively in the esophagus as on the cervix.

ESOPHAGEAL IMPLANTATION INTO STOMACH AFTER INTRATHORACIC RESECTION OF THE ESOPHAGUS FOR CARCINOMA

A NEW METHOD

HERMAN FISCHER, M.D.
NEW YORK

With the invention of differential pressure for intrathoracic operations a large number of enthusiastic workers have battled with the problem of helping the unfortunates who are suffering from carcinoma of the esophagus. It has been a long and hard struggle, full of disappointments, and it seemed for a time that the surgeon would be vanquished on this battlefield with a foe so unrelentless and cruel. For nine years our surgical profession has fought against seemingly unsurmountable odds, until Torek proved that a full victory could be gained surgically over this dreaded disease by complete exenteration of the esophagus in cases of carcinoma. A second success was scored by Eggers by the same method. Both of these cases were presented to this society last year at its meeting in Rochester, Minn.

In our early endeavors to resect the esophagus it was natural to try to find a method of reuniting the two stumps of the esophagus or to establish a union between the stomach and the esophagus in lesions situated in the lower portion of the esophagus immediately above the diaphragm. The different methods, some of them very ingenious and complicated, have been mentioned by me in a paper read before this society in April, 1922. All these methods were failures, however, as invariably, at least in the human esophagus, insufficiency of the suture line with subsequent infection occurred which led to the speedy death of the patient. Therefore, all further attempts at the reconstruction of the lumen of the esophagus have been abandoned by men who have continued in this line of work. Up to the present I myself have taken the stand that the rational treatment in cases of carcinoma of the esophagus is total exenteration. End-to-end anastomosis of the stumps of the esophagus should not be attempted. However, I never dismissed the idea from my mind that a method should be found which would make it possible to anastomose the stomach and the esophagus in such a way that infection and leakage could not occur. This method would be applicable only in cases in which the seat of the lesion would be in the lower part of the esophagus or at the cardia of the stomach; in short, in lesions that are located in the neighborhood of the esophageal hiatus. In tumors in this locality where only the lower third of the esophagus must be sacrificed a complete exenteration of the organ seems to be an unnecessary procedure.

For such cases I should like to propose the following procedure: The opening of the thorax is accomplished by the usual incision in the eighth or ninth intercostal space, from the chondrocostal junction to the scapular line. If more room is necessary, the incision can be carried upward along the paravertebral line, cutting through the ninth, eighth, seventh and sixth ribs close to the vertebrae, with careful ligation of intercostal vessels. Under differential pressure the pleural cavity is widely opened and the field explored. If the condition is operable, the esophagus with the tumor is bluntly isolated from the covering of mediastinal fatty connective tissue and pulled forward by a piece of rubber tubing or a piece of gauze looped around it (Figs. 1 and 2). The pleural cavity and the surface of the lung are now well protected by large silk compresses that are soaked in warm, sterile

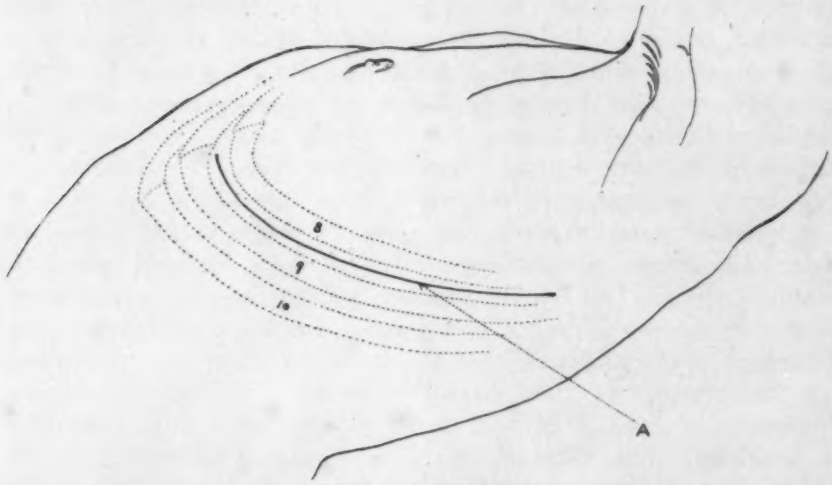

Fig 1.—*A*, incision.

olive oil; these are then covered by hot physiologic sodium chlorid gauze compresses. I found these oil soaked silk compresses preferable to ordinary gauze sponges because they injure the pleural epithelium less and keep the thoracic organs from cooling, which, I think, is an added factor of safety; besides, they are impregnable to fluids and thus insure asepsis. If the vagi nerves are adherent to the tumor both should be cut. The next important act is the supradiaphragmatic phrenicotomy as advocated by Sauerbruch. The left nerve is seen descending on the left side of the pericardium accompanied by the pericardiophrenic artery and vein; where it reaches the diaphragm it is isolated from its accompanying vessels and cut. This immediately relaxes the diaphragm, which not only makes the subsequent fixation of the stomach to the cut edge of the diaphragm easier but also prevents the respiratory movement of the diaphragm on that side; this

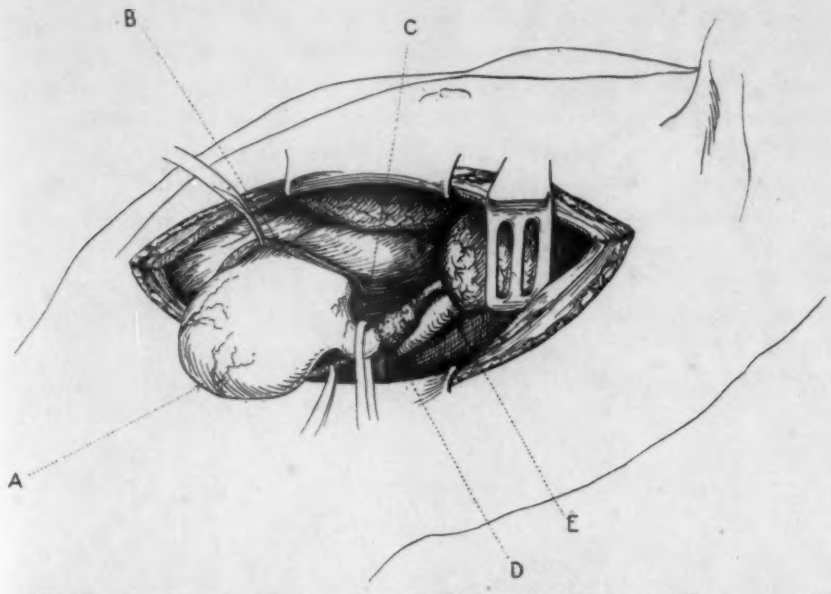

Fig. 2.—*A*, stomach; *B*, cut edge of diaphragm; *C*, vagus; *D*, tumor, and *E*, aorta.

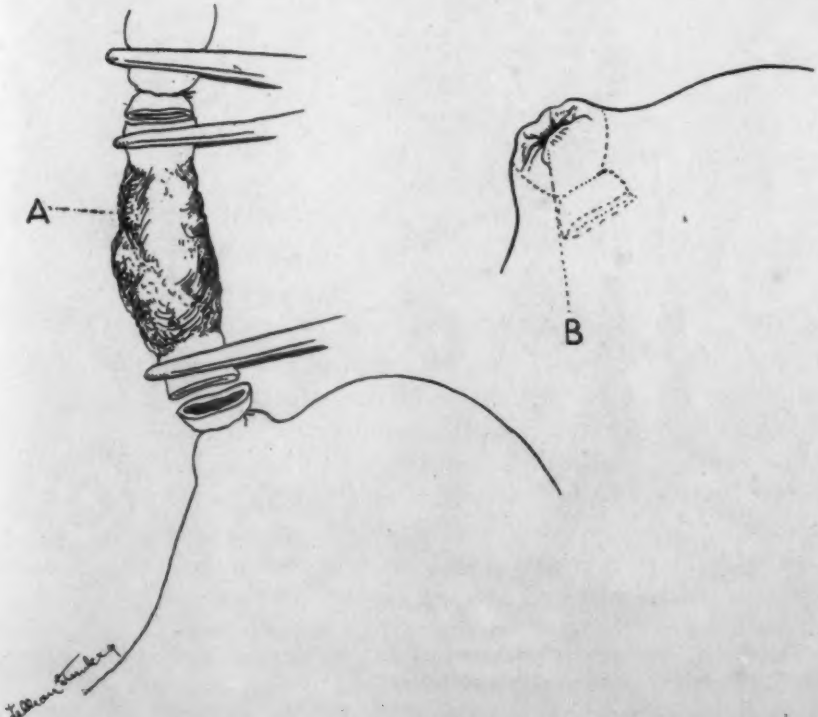

Fig. 3.—*A*, carcinoma, and *B*, invaginated stump of esophagus into stomach.

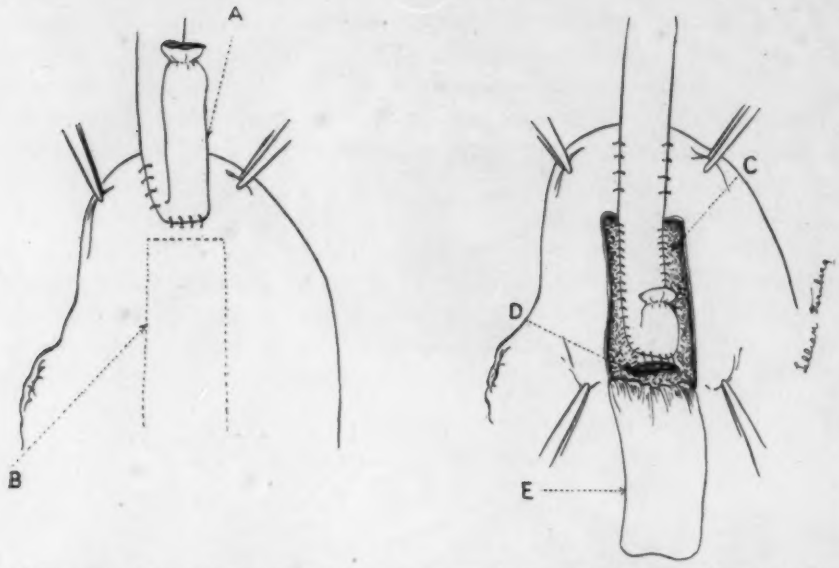

Fig. 4.—*A*, esophagus reflected to show posterior sutures; *B*, outline of seromuscular flap; *C*, submucosa; *D*, incision into submucosa and mucosa, and *E*, flap reflected.

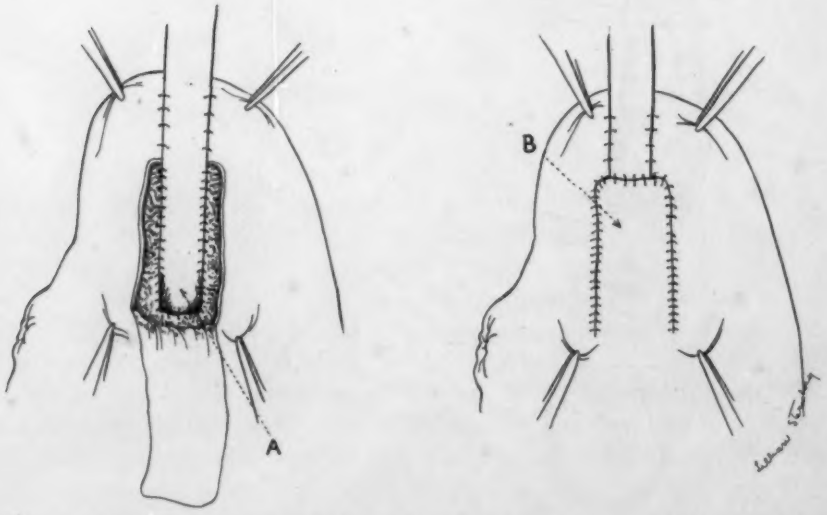

Fig. 5.—*A*, esophagus stump inserted into incision and anchored by sutures, and *B*, flap laid over esophagus and sutured.

insures an undisturbed healing of the anastomosis. The diaphragm is now caught up between two forceps and an incision is made in the direction of its fibers. The peritoneum is opened at the same time. The incision is then prolonged upward to the cardia and downward to the insertion of the twelfth rib. Its cut edges are caught up by clamps. The stomach is now pulled up into the thorax. The small and large omentum is tied and severed from the stomach to mobilize it to the extent necessary for the contemplated anastomosis with the esophageal stump. The lower portion of the esophagus is now bluntly freed from its bed. After careful protection of the abdominal cavity with gauze pads, two crushing Payer's forceps are applied to the esophagus below the tumor, the two crushed portions are tied by a silk

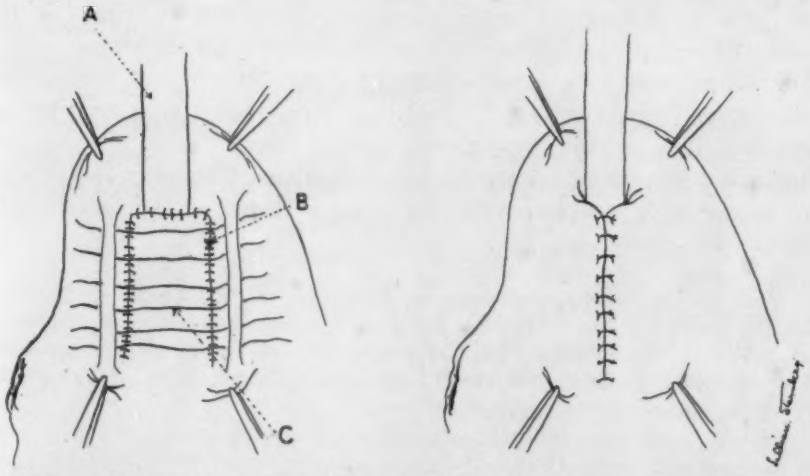

Fig 6.—*A*, esophagus; *B*, flap reflected and sutured over esophagus, and *C*, Lembert sutures.

ligature and the esophagus is divided between them by the cautery. The cardiac stump is then inverted into the stomach after Doyen. The same procedure is followed several centimeters above the tumor; this finishes the resection.[1] The fornix of the stomach is now caught up by two Allis clamps and brought in contact with the esophagus 4 or 5 cm. above its cut end. It is here fastened to the stomach wall by several chromic gut sutures on its sides and posterior wall. A seromuscular flap is now outlined, with its base downward, its width twice as large as the diameter of the esophagus. The base of the flap must reach 2 cm. below the tied end of the esophagus. In the dissection

1. For the ligature of the oral end of the esophagus plain catgut should be used. This will be digested by the stomach juice after a few hours and the esophagus will then become patent.

of this flap, great care has to be taken not to injure submucosa and the mucosa. On the living subject this is not difficult as our experience in stomach resections has shown. One centimeter above the base of the reflected flap, a small transverse incision is made into the submucosa and the mucosa and the stomach are opened. The esophagus wall is now fastened by sutures to the submucosa and the esophagus stump inserted into the stomach (Fig. 4). A suture of the lower edge of the submucosa-mucosa incision with the anterior wall of the stomach follows, and the flap is now reflected onto the anterior surface of the esophagus and sewn into place (Fig. 5). A broad Lembert suture of the serous coat of the stomach covering the flap finishes the anastomosis (Fig. 6). The edges of the incision into the diaphragm are now carefully sutured to the stomach and the thoracotomy wound closed.

Although I have not been able so far to use this operation on the living subject, experimental work on the cadaver has shown me, to my satisfaction, that it is feasible without great difficulty. I present the idea before this society in the hope that it may be given a trial by the members if a suitable case should present itself. It is advisable to establish a jejunostomy instead of the usual gastrostomy in these cases for preoperative and postoperative feeding, in order not to interfere with the mobility of the stomach.[2]

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2. A few weeks after this paper was read, Dr. F. N. G. Starr of Toronto, Canada, wrote me that he had operated on a patient who was suffering from carcinoma of the esophagus, situated near the cardia of the stomach, in November, 1922, by almost the identical procedure advised by me. He describes the operation in a letter to me as follows:

"It was found that the carcinoma of the esophagus was situated just at its junction with the stomach. The pneumogastric nerves were separated from the esophagus. The diaphragm was then opened and the stomach drawn up into the chest. The esophagus was cut across well above the growth and the upper portion of the stomach resected. This opening in the stomach was closed and a loop at the cardiac end of the stomach was brought up and punctured, and the lower cut end of the esophagus was drawn through the opening and held with four stay sutures, and thus invaginated into the stomach. The serous coat was then pulled off this part of the stomach and the muscular coat of the stomach sutured to the esophagus; then the serous coat was brought up over the line of suture, making a nice looking job. The opening in the diaphragm was then closed by continuous sutures, the stomach being fastened with the stitch in an effort to prevent its retraction if the abdomen should become distended.

The patient did beautifully for five days, and then suddenly died, apparently from a pulmonary embolus. She was taking liquid food and soft food with great comfort and apparently digesting it. We had the privilege of removing the specimen subsequently and it showed that union had taken place and a perfect anastomosis had occurred."

RADIUM IN CARCINOMA OF THE ESOPHAGUS

METHOD OF APPLICATION

SIDNEY YANKAUER, M.D.
NEW YORK

The method of treatment of carcinoma of the esophagus which I am using is as follows: As soon as the diagnosis has been made by the esophagoscope and the distance of the carcinoma from the upper teeth has been measured, the next thing to be done is the gastrostomy. During the time it takes for the tube to become free the carcinoma has lost some of its inflammatory swelling; then a string is swallowed by the patient and fished out of the gastrostomy wound. If the patient cannot swallow the string it may have to be pushed through with the esophagoscope.

When the string has been fished out of the stomach the rest of the procedure is simple if the radium is contained in a radium chain. This chain consists of several links which are preferably made of platinum but can also be made of brass, in which the desired dose of radium is placed. I have used three links in the chain, the area covered by this being 6 cm. The cavity in the links is 1 cm. long and there is 1 cm. of space between the cavities. This is about the extent of the radium emanation. The radium chain is covered with a rubber covering to cut out the short waves, and the two strings are tied to it. The longer string has a knot tied at the distance from the chain which corresponds to the distance of the upper end of the growth from the teeth. The other string is tied to the gastrostomy string and pulled down. When the knot is opposite the patient's teeth, we know from fluoroscopy that the radium chain is exactly in the region of the carcinoma. The introduction of the radium in this way is exceedingly simple. It need not be done by the physician himself. Any nurse can do it. In regard to the use of small doses of radium over a prolonged period of time, if we use too small a dose of radium we are apt to cause fibrosis on the surface of the carcinoma which will act as a screen and prevent the radium from acting deeper, so I have not used the small doses mentioned, but I have used 100 millicurie hours, applying the radium over two or three days.

The therapeutic results are due in part to the gastrostomy and in part to the fact that there is a string passing through the carcinoma. However it is produced, it is a fact that in the few cases that I have treated, there has been immediate relief, particularly of the difficulty of swallowing. Patients who were unable to swallow even two weeks after the gastrostomy were able to swallow soon after the treatment was begun.

DISCUSSION ON THE PAPERS OF DRS. STONE, TOREK, JACKSON, FISCHER AND YANKAUER

DR. JAMES T. CASE, Battle Creek, Mich.: In my experience, one of the most discouraging fields for radium therapy has been cancer of the esophagus. I sincerely hope that the method of Dr. Yankauer may give more promise. I have used a similar method for a number of years and described it in the *American Journal of Roentgenology and Radium Therapy* (**10**:859 [Nov.] 1923). Dr. Yankauer's well known ability with the esophagoscope should enable him to do this work with maximum efficiency.

I am not enthusiastic about the results of radium treatment of cancer of the esophagus for I have alive today only one patient in a series of about twenty that I have followed up, and as the time goes by, I am beginning to feel that this is possibly a case of mistake in diagnosis. Such a mistake seems hardly possible for the roentgen-ray findings were characteristic. The age, the history, in fact, every aspect of the case points to malignancy, but the patient is now alive more than three years after the treatment. (This patient died Nov. 1, 1925.)

I am thoroughly convinced that of the benefit accruing to any patient with cancer of the esophagus from a combination of gastrostomy and radium therapy, 80 per cent. or more of the good depends on the gastrostomy and the remainder on the radium therapy. Life is prolonged, I am sure, by this combination, but I think the gastrostomy is largely responsible for the benefit. I therefore feel that the first thing to accomplish in a case of carcinoma of the esophagus is relief from obstruction and rest for the lesion. Whether this is best accomplished by gastrostomy or dilation of the esophagus is a matter that has been discussed. Various opinions have been offered. From the Mayo Clinic we have recently had a paper recommending dilation of the esophagus rather than gastrostomy. I personally feel that gastrostomy is preferable in that it not only relieves the obstruction but also avoids instrumentation of the esophagus and gives the esophagus rest from food. I feel that the instrumentation necessary for dilation of the esophagus in a case of malignancy is detrimental for at least two reasons:

First, I have the impression from my own experience that instrumentation favors metastases.

Second, instrumentation certainly gives the physician a lot of anxiety for there is unquestionably considerable danger of a fatal mediastinitis following forcible dilation of a malignant stricture. The sooner we give the patient the benefit of a gastrostomy, the better off he is. Most of these patients are extremely undernourished when they come to us. By doing a gastrostomy according to the technic described by me in the paper above referred to, inserting a duodenal tube through the gastrostomy tube and on through the pylorus into the duodenum immediately after the operation, we are able to begin nourishment immediately and the patient soon gets into a much improved physical state. I believe the sooner we do this the better it will be for the patient. For fear I am not understood regarding the technic of the gastrostomy, I will merely state that the gastrostomy tube should be led into the stomach in such direction that it points toward the pylorus and that the gastrostomy tube introduced should be of sufficient size to permit the passage of a duodenal tube through it. Thus, immediately following the operation, that is, while the patient is still on the operating table, a duodenal tube can be passed through the pylorus into the duodenum and even on down into the jejunum. As to whether it has gone into the duodenum, check can be made by fluoroscopy or by a film made with

the bedside roentgen-ray apparatus. As soon as the tube is placed in the jejunum, the patient can be fed immediately and adequately. The relief obtained in this manner is considerable.

I feel that the gastrostomy is an important and useful means for applying radium without much esophageal instrumentation. In other words, a thread can be swallowed by the patient to be used for introducing the radium. I have not had a single case in which a fine silk thread swallowed by the patient did not come down into the stomach whence it could be recovered by a hook through the gastrostomy opening. A stronger thread is then tied to this one and pulled down and out through the gastrostomy opening. The radium applicator made up in such form as is suitable to the shape and size of the lesion is then attached to the upper or lower end of the heavier thread and by traction from above the radium can be pulled up into the lesion from below, or vice versa, down from above. I always bring out the thread through the tube in the gastrostomy opening to prevent the thread from sawing the edge of the wound or the edge of the cardiac orifice. Under the traction necessary to apply the radium the end of the gastrostomy tube can be forced up even to the lower edge of the lesion.

The alternative method, that of the introduction of radium needles or radium seeds directly into the lesion, or by the introduction of the radium applicators attached to the intra-esophageal sound, has been discussed by others. I have avoided this method for fear of stirring up the lesions by the instrumentation as I have little hope of really curing these patients by radium by any method that I have been able to apply up to the present time.

The chief objection to the use of radium is that it is distinctly a local application. I mean a very much localized application. The studies of Friedrich and later those carried on by Schmitz, working in Friedrich's laboratory, have shown us that the zone of activity of a radium application is extremely limited and that we have to go only a few millimeters away from an applicator to reduce the effect of that radium to one-tenth, more or less, and one-tenth the effect of that radium is not sufficient to get the outlying foci of the disease.

I therefore feel that a gastrostomy, plus the intra-esophageal radium application after the manner I have suggested, should be supplemented by roentgenotherapy through external fields.

Dr. Carl A. Hedblom, Madison, Wis.: I am inclined to believe that at the present time more harm than good may result from the consideration of radium treatment in carcinoma of the esophagus. There was a time when perhaps all of us hoped and expected that radium would supplant all attempts at surgical extirpation. At that time we were all eager to learn more about methods and results following radium treatment. But now that it is generally agreed on the basis of actual test that it does not cure, it seems to me we should direct our efforts toward correcting the false impressions gained by the laity and a large proportion of the profession, that "radium may cure" the condition and that we should concern ourselves with methods that give some promise of success rather than with those that seem to have proved useless.

I have seen many patients who, in face of the gravity and uncertainty of surgical operation, have decided to "try radium first" on the assumption that it might bring about a cure. If these patients were told the known results of radium treatment they would at least have no reason for basing their decision on a false hope.

I do not feel qualified to discuss the technical aspects of Dr. Yankauer's paper nor would I discourage the further use of radium as a palliative measure.

What I am trying to emphasize is the importance of this association making its opinion, which I believe is pretty much unanimous, known to the rank and file of the profession to the end that a patient who has carcinoma of the esophagus should not be advised to "try radium first" in the possibly early operable stage.

The crux of the whole matter of surgical treatment, namely, early diagnosis, was brought out by Dr. Torek and by Dr. Jackson, and prompt oesophagoscopy is a means to early positive diagnosis.

Dr. Howard Lilienthal, New York: In deciding on a preference in the technic of operation on the thoracic esophagus we must remember that only the transpleural method has received an approximately fair trial. Also, that a proportion of operators testing the purely mediastinal method become discouraged on finding that they have accidentally wounded the pleura and, abandoning it, conclude the procedure transpleurally.

We must also remember that whether or not we pass through the pleural space in our approach, the work on the esophagus cannot be carried out except within the mediastinum. We have, then, in the transpleural method the probability of infecting both pleural sac and mediastinal space, while in the posterior mediastinal approach, there is a good chance that the pleura will escape injury and contamination. This is the first point in favor of a direct approach without pleural complication.

The purely mediastinal approach aims to preserve the natural relations of the alimentary tract so far as this is possible—a second point in favor of this method. At the same time it saves the respiratory capacity of the lung and the symmetry of the thorax.

The danger to life is no greater in the mediastinal than in the transpleural procedure, perhaps even not so great. The exploration to determine operability can be carried out absolutely without pain by regional anesthesia. The direction and extent of the incision and the number of ribs divided are exactly the same as in the procedure devised by Torek. The operation can be performed in one or in several stages and it lends itself perfectly to the eventration of the stomach with esophagogastric anastomosis.

Another method, that of Levy, has been suggested. It comprises multiple subperiosteal long resection of several ribs with preliminary extrapleural collapse of the lung, then exposure of the esophagus in the mediastinum. After resection of the tumor, the divided upper segment of the gullet is implanted in the chest wall as a stoma and is then connected by rubber tube or by a plastic operation with a previously formed gastric stoma. Hedblom made use of this principle in his brilliant case of combined resection of cardia and esophagus. He deliberately entered the pleura, collapsing the lung by stages so that there was no sudden dyspnea at the crucial part of the procedure, the transplantation and resection of the esophagus. The great deformity with the loss of pulmonary function was hardly worth considering compared with the surgical perfection of the extensive malignant growth extirpation.

A method of my own for the resection and direct union of the divided esophagus with the stomach, in one or two stages, is by the posterior mediastinal route and, to my mind, it seems capable of sufficient development to be applicable to all except the growths as high as the second or third rib and possibly even to these. Briefly, it is as follows: posterior mediastinotomy; mobilization of the gullet; enlargement of the hiatus by incision; eventration of the gastric fundus; direct anastomosis with invagination of the gullet into the stomach without the slightest tension, and resection of the cardia, if neces-

sary, at another stage. I have done this operation once, proceeding as far as the anastomosis. Death from pneumonia in five days. Postmortem examination revealed the complete adequacy of the union. There was not the slightest leakage. I trust that this method may receive the trial I think it deserves.

Cancer surgery of the esophagus differs in technic only from cancer surgery elsewhere. Its final success will, after all, depend on the patient's presenting himself for operation while the disease is still confined to the organ in which it originated.

Dr. Willy Meyer, New York: We who are interested in the best treatment of cancer of the esophagus have been waiting, patiently and impatiently, for just the kind of presentation of the subject by specialists in radium therapy that we have had. Some seven years ago the late Dr. Henry H. Janeway discussed the same subject before the New York Society for Thoracic Surgery, in his usual straightforward way. At that time he told us that so far he had had thirty-five cases of esophageal malignancy under his care for radium treatment and that not in a single case had he seen results approaching a cure. In one patient, with the best result of all, unfortunately the diagnosis of carcinoma could not be established definitely.

A few years ago when writing on the surgery of the esophagus and going over the literature of the world, I found two cases reported from abroad in which the specialists thought they had cured cancer of the esophagus by means of radium. Of course, we have to wait for the report on later results before we can accept these cases as being really cured. The question before us then resolves itself simply into the answer to the question, "Can the specialist, who uses radium, cure cancer of the esophagus, and if he can, in what percentage?"

We all are certainly most grateful to Dr. Stone for having come to Washington to tell us the experience they have had at the General Memorial Hospital in New York, where Dr. Janeway worked. He, too, said today that they did not have a single case on record in which they had succeeded in curing cancer of the esophagus by means of radium. He spoke of the necessity of early gastrostomy. Naturally, he as well as we all know that gastrostomy for this purpose is nothing but a palliative operation, with 100 per cent. mortality in the end.

It was mentioned by me at our last meeting at Rochester a year ago that it had been a most unfortunate occurrence for the radical operation that the operation in its newest garb was born and introduced into operative surgery at the same time that radium had begun to be employed for local and deep ray therapy. If this had not occurred, the surgeons, beyond a shadow of a doubt, would have gotten these cases for operation, since the thorax had just been opened definitely and safely to the surgeon. But it did occur, and, naturally, because the surgeons could not promptly and quickly show satisfactory results and a series of cases operated on successfully, and further, because the operation is to be considered a big and serious one up to the present day, colleagues and patients turned to radium. Doctors, using radium, received the bulk of these cases for treatment, while the operative surgeons got few. Only now and then a case has drifted into their hands within the last twelve years, and then almost invariably in a far advanced stage, when radical work has been rendered impossible technically.

So we waited. We had to wait in order to be able to compare results of operative surgery with those obtained by means of radium. We heard it seven years ago, and we have heard it again today, that our radium specialists cannot show a single case of cure in cancer of the esophagus.

The Lenox Hill Hospital of New York, on the other hand, can show two patients who were cured by operative surgery. Dr. Torek's patient lived twelve years, as he just told us, and then the patient, almost 80 years old, died in consequence of a pneumonia. The second patient was successfully operated on by Dr. Eggers, and reported at our last annual meeting. True, the operation was done only last year. However, his patient, too, like Dr. Torek's, came early and the glands removed by him were not yet involved. Were it not for the four plus Wassermann reaction found in the patient before operation, we could almost venture to make the same definite prognosis for final cure as Dr. Torek's patient showed.

Thus, we have the results of operative surgery against those of radium treatment, though still in only a few cases. And we have certain definite results in favor of operative surgery which we do not have, at least as yet, for radium. It is the same experience with cancer of the esophagus as with any other operation for cancer that is radically operable in comparison with the results obtained by radium treatment. I am sure that, with few exceptions, the majority of the surgeons of our country claim today that the treatment of patients suffering from carcinoma, which appears to be operable radically, belong to the surgeon. The after-treatment, when the wound has healed, as well as the patients who are considered or found to be inoperable radically may be left to the use of roentgen rays or radium.

I think it is the duty of all of us who take an active interest in this chapter of thoracic surgery to stand together and assert that the time has come for the pendulum to swing back to surgery, now that a recognized specialist has stated in open meeting the persistent failure of radium to bring lasting help to these unfortunate patients.

Today, if the trained surgeon has a case of cancer of the esophagus, he should make an incision, best transpleurally, to my mind, and see whether the tumor can be radically extirpated. In other words, he should perform an exploratory thoracotomy and find out. If feasible, he will resect; if beyond surgical help, he will close up the incision, and most likely see the patient recover from the operation. For exploratory thoracotomy, properly carried out and treated afterward, involves no more risk than an abdominal exploration. The patient then should be sent to the specialist who uses radium, as just stated.

But to be successful oftener, early diagnosis is necessary. We have discussed "early diagnosis" for years. We have emphasized again and again that a patient who has difficulty in swallowing should not be treated by the family physician or at the dispensary and prescribed for with a powder or a pill, but should be considered to be as seriously ill as a person with acute appendicitis. He is a hospital patient, who needs a correct diagnosis as soon as possible. And that can be established only at the hospital in which one has the services of a trained esophagoscopist at his disposal. Of course, a patient of means can have this done at the private office of the specialist. But it seems to me that he, too, is better off when the examination is carried out at the hospital so that he can rest for some time after it. Nobody has a right to introduce the bronchoscope, still less the esophagoscope, unless he is an expert. The human esophagus has a thin wall; extreme care is required.

The work of the roentgen-ray specialist comes next. He started in great style and tried to help us ingeniously in establishing an early diagnosis some ten years ago. But with him, too, the trouble was, and still is, that he does not

get these cases early enough to develop the methods and find ways and means to corroborate on the plate what the esophagoscope may have shown on direct inspection.

Dr. Jackson has shown us in his beautiful chalk drawing how a small tumor can be seen inside the esophagus early, when it has just commenced to project into the lumen of the canal. An expert is allowed to bite out a small piece, superficially, for examination. Of course, the greatest experts sometimes produce a perforation in this way. It is sad when it occurs. But such accidents do not represent an objection against the use of the esophagoscope and the bisecting that is so desirable in these cases.

In order to push the whole chapter forward in the right direction, and that as quickly as possible, I would venture to repeat what I said at our meeting last year, viz., that it would be splendid if the American Society for the Control of Cancer would see its way clear to take a hand in this question and instruct the laity as well as the profession through the proper channels of the eventual serious meaning of the first signs of difficulty in swallowing.

I shall make one brief remark with reference to a point in the resection of a cancer of the esophagus, that is regarding the immediate after-treatment. The matter has been in my mind for many years and seems to me of great importance.

Since 1909 I have done eight complete resections of the esophagus for cancer, and two antethoracic transpositions of the proximal stump after division of the esophagus above the malignant stricture—which could not be removed on account of a too far advance of the tumor—for the purpose of returning to the patient the ability of swallowing. One of the eight patients in whom resection was done, a man well in the sixties, lived six days after the operation. We all expected that our hospital would have the satisfaction of seeing another patient recover after this operation. It was done not long after Dr. Torek's successful case and according to the method employed by him. On the sixth day after the operation the patient suddenly got worse. We aspirated the chest and found an effusion of serosanguineous fluid containing staphylococci and streptococci. In spite of prompt drainage the patient died. The cause of our disappointment, I think, was my not having added air-tight drainage of the pleural cavity at the completion of the operation, the drainage I had planned to employ previous to the operation. But we all then were under the influence of Dr. Torek's splendid result, and he had not drained. At the last moment I omitted the drainage. I certainly admire Dr. Torek's work and result, and yet I believe that these patients with esophageal resection stand a much better chance to recover if the amount of pleural effusion, which is bound to occur in the greater percentage of patients after the operation under consideration, can drain off in a safe way during the first hours and days of after-treatment. Then is the greatest chance for absorption and infection. It certainly must be considered a most fortunate occurrence if the fluid in the pleura remains sterile. The esophagus is the habitat "par excellence" for bacteria. In spite of dividing it with the cautery, after safe closure of both ends by ligature and burning the stumps thoroughly, some of the micro-organisms from the ruffled folds of the mucosa are apt to infect the sensitive pleura. The unavoidable result is a nonsterile effusion, usually of serosanguineous character. This should have the chance of draining off, beginning right at the time of completion of the operation.

Therefore, I hope that my colleagues, in every case of transpleural resection of the esophagus for cancer, will add the air-tight drainage of the pleural cavity. Then, I believe, they will have done the best for their patient. Nothing is lost by adding it. But the great danger that will most likely follow the effusion of

infected fluid into the pleural cavity is averted by a single stab and the simple introduction of a drainage tube into the pleural cavity through this stab in air-tight fashion, to be removed after a few days. I advocate this type of drainage after the great majority of intrathoracic operations in which the previously healthy pleural cavity has to be entered or traversed. It represents a safety valve.

Dr. Carl Eggers, New York: The subject has been so well covered that I don't believe I need add anything. He has covered everything I could have said.

Dr. Carl A. Hedblom, Madison, Wis.: I can only repeat what Dr. Eggers has said. I think Dr. Torek has emphasized the one important point outside of technical considerations, namely, early diagnosis, and Dr. Jackson has shown us a means of making early diagnosis. I am strongly of the opinion that the problem lies not so much on the technical side as on that of obtaining the patients early.

Dr. Charles Gordon Heyd, New York: In the last year I have seen six cases of carcinoma of the esophagus. All six were diagnosed carcinoma of the esophagus by the interns. In other words, the clinical condition was such that diagnosis was readily apparent from the history. The lateness of these patients coming to the hospital for relief is an index as to the diagnostic intelligence of the community and must be frankly accepted as a field for education. We performed gastrostomy on all six of them. Two failed to obtain any benefit from the gastrostomy and died within a short time. To my mind these two cases indicate that palliative operations for conditions of nourishment, like palliative operation for intestinal obstruction, must be done while the patient still has some recuperative power at his command. In other words, we can pour into the stomach through the gastrostomy tube or through a duodenal tube sufficient caloric nourishment to sustain life, yet the patient may be unable to assimilate it. Two of the patients died after a variable time, from a month to three months later. One of the patients refused any further treatment and one elected to have an esophageal resection performed. I followed Dr. Torek's technic of major thoracotomy. Under rectal anesthesia the esophagus and tumor were dissected freely from below the arch of the aorta well up and into the neck. This portion of the operation required an hour and eighteen minutes. We closed the thoracic cavity without difficulty but I think made technically an insufficient closure of the superior aperture of the thorax. We allowed the patient to rest for an hour in the etherization room. At the end of this time I brought the esophagus out through the neck. This portion of the operation occupied about twenty minutes. The patient was then given 800 cm. of physiologic sodium chlorid solution intravenously. We did this to anticipate any shock resulting from the operation. I now think that was a mistake as his right heart was already overworked. When he returned to the ward, the pulse was 90; the skin was warm. I saw the patient at 4 in the afternoon and he had reacted well and was doing nicely. I saw him again at 8 and he was still in most excellent condition. An hour later, the house surgeon telephoned me that the patient had died suddenly.

If I myself were told "You have a carcinoma of the esophagus," I would not accept treatment with roentgen ray or radium; I should prefer to take my chances with surgery.

Dr. Franz Torek, New York: It seems after the discussion we have gone through that there can be only one conclusion, namely, that carcinoma of the esophagus should be treated surgically and not in any other fashion. As regards special points, Dr. Stone and Dr. Case have both called attention to

the fact that gastrostomy, as we all have noticed, often relieves to some extent the obstruction in the esophagus. As a parallel to this we all have observed that in consequence of the palliative treatment of carcinomas of the rectum by colostomy the tumors have sometimes shrunk to half their former size. This, as I say, we are all familiar with, but there is one danger in mentioning it without more explanation, namely, that some observers may be led to think that the tumor actually diminishes in size as a consequence of gastrostomy. That is not the case. The tumor proper is just as large after the gastrostomy as it was before, but owing to the constant insult that was brought to bear on the constricted portion of the esophagus by attempts to force food through it, previous to gastrostomy, edema, partly inflammatory in its nature, has been formed around the tumor, and this edema has caused an apparent increase in the size of the tumor. When these insults to the constricted esophagus have been removed by the gastrostomy, the edema subsides, and the tumor returns to its normal size. No one should believe that gastrostomy actually reduces the amount of carcinomatous involvement.

Dr. Case also mentioned the possibility of using the duodenal tube through the gastrostomy opening for the purpose of immediate nourishment. I must say that so far I have never yet found the necessity for such a procedure. It has been my habit at the end of the gastrostomy to pour something immediately into the patient's stomach while he is still on the operating table, without the use of the duodenal tube. The duodenal tube is not necessary. We may feed our patient at once through the gastrostomy opening.

Dr. Jackson remarked, somewhat in the manner of criticism, that I mentioned all other signs of the disease before speaking of esophagoscopy. I may answer to that that I appreciate the value of the esophagoscope as much as anybody; I mentioned the other signs first because I followed the regular order in which they appear. Patients do not come to us with the request that they be examined by the esophagoscope. They have been taught that they should undergo a health examination once in a while, but they are sadly ignorant about the esophagus. Consequently, we have to teach them the importance of early vague symptoms and the desirability of consulting a physician. Knowing that most of the patients neglect consulting a physician for the early symptoms, I naturally laid special stress on them rather than on esophagoscopy.

Dr. Fischer's operation looks very pretty, indeed. But it assumes that a great deal of esophagus is at command for implantation through such a long stretch of stomach. In all my experience, I cannot remember a single case in which I would have had at command as much esophagus as Dr. Fischer showed was needed for implanting into the stomach. I wish Dr. Fischer all possible success when he tries it, but I have my serious doubts that he will be able to execute it.

Dr. Hermann Fischer, New York: I have nothing further to add, except to answer Dr. Torek that one can resect from 8 to 10 cm. of esophagus on the cadaver with this method of anastomosis. I have had so far no opportunity to try the operation in the human subject. I said in the beginning that this operation is indicated only in cases of carcinoma of the esophagus in which the tumor is confined to its lower portion near the cardia. The method has a limited field but there undoubtedly are cases that could be dealt with in this fashion.

Dr. Sidney Yankauer, New York: The time will soon be here when the men working with radium for the treatment of cancer of the esophagus will

bewail as loudly as the surgeons now do that they do not get the cases to treat early. They, too, would be right. If they could get the cases early, they would have a better chance with the patients. There is one thing in favor of surgery without radium. It is a fact that any tissues that have been subjected to treatment with radium are poor tissues for surgery, because the nourishment of those tissues is below par, and they are likely to give bad results if surgery is used. Therefore, if we do get an early case it would be wrong to subject that patient to radium treatment first and then to use surgery. The surgery should be done first.

The main thing that has been brought out in this discussion is the fact that what the surgeon needs and what the radium therapist needs is early cases. What we need is early diagnosis. We are not going to get early diagnosis by asking for it. The only way one can get early diagnosis is by finding out what the symptoms of the patient are at the early stages, and the place to find that is not in the surgical clinic but in the stomach clinics, where the patients go in the early stages. It is the stomach specialist who has to find the cases early.

THE SIGNIFICANCE OF VITAL CAPACITY IN INTRATHORACIC THERAPY *

J. L. YATES, M.D.
MILWAUKEE, WIS.

PART I

Vital capacity, the largest expiration following the deepest inspiration, varies with age and sex, height and weight, health and disease, and after periods of rest and exertion. It is a fair criterion of life, reaching its peak when physiologic competence is highest, diminishing as incompetence increases and becoming zero when respiration ceases.

A just evaluation of the therapeutic significance of vital capacity depends primarily on recognition of the anatomic and physiologic factors that establish it and secondarily on knowledge of their interrelationships, which control it. These are the means to understand the causes and effects of the numerous, considerable and at times abrupt fluctuations in vital capacity known to occur in health and in disease spontaneously and to be provoked by operations. They are also the means to better therapy.

Answers to the questions implied are to be found in studies of the processes that control oxygen metabolism, particularly those that supply oxygen to the body and deliver it throughout the body, because the utilization of oxygen by the body is only indirectly pertinent to this subject.

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* The work on which this paper is based was aided by the American Red Cross and carried on in the Laboratory for Surgical Research of the American Expeditionary Forces and in Columbia Hospital, Milwaukee.

* This paper introduced a prearranged discussion of the significance of vital capacity. A moderate time limit was imperative. Presentation of the subject, however, would have been of little practical value unless methods to control vital capacity were established on a physiologic basis. The basis is Dunham's air cell capillary gear, and its existence was certain to be questioned.

In order to include the most important features the presentation was divided into two parts, the first to consider the main subject, and the second to elucidate the actions of an air cell capillary mechanism. The second part was given in the time allotted to close the discussion. Even so it was impossible to proffer evidence to support all the assertions made. Evidence not presented can be found in the following articles by me: Wounds of the Thorax, Oxford Surgery, New York, 1920, p. 665; Effects of Acute and Chronic Pneumothorax, Am. J. M. Sc. **165**:1 (Jan.) 1923; Significance of Vital Capacity in Intrathoracic Therapy, Arch. Surg. **10**:477 (Jan.) 1925.

FOUR FACTORS IN EXTERNAL RESPIRATION

The amounts of oxygen required by a body are determined by the metabolic rates of its cells. Oxygen is introduced by the combined actions of the breathing and circulatory apparatuses so coordinated as to aerate the blood, passing through the pulmonary capillaries. This function, external respiration, is fundamental in life and to that extent is the most important activity of the living. Four factors are concerned in its accomplishment: (1) unit volumes of ventilated air in the alveoli, which fluctuate with degrees of pulmonary inflation; (2) the areas of alveolar epithelium, determined by the extent of inflation; (3) unit volumes of blood in the pulmonary capillaries, chiefly influenced by blood pressures since there is little vasomotor control of the vessels in the lesser circuit, and (4) the expanse of capillary endothelium, which varies with fluctuations in the unit volumes of blood.

Observations on the physiologic compensations occurring in normal life, under varying conditions of rest and exertion and on the adaptations to morbid states developed spontaneously or induced experimentally or by operations, indicate Nature's attempts to maintain accurate relationships between the four factors. Aeration of a volume of blood during the short interval, possibly one second, taken by it to pass through the pulmonary capillaries is facilitated by broad surface contacts between air and blood which are provided through the apposition and the tenuity of their limiting membranes, the alveolar epithelium and the capillary endothelium. Bunting noted that the larger the volume of blood, the greater the need of expeditious aeration, and the thinner the endothelial and epithelial membranes intervening between blood and air. Moreover, it appears that if either of the two chief factors, i. e., the unit volumes of air and the unit volumes of blood, varies, the other principal factor and the two lesser factors are promptly and correspondingly modified. Some form of governor correlates the unit volumes of air and blood, and since the pulmonary vessels are subject to no exact vasomotor control, and the air cells to no direct nerve control, this governor must be physical rather than physiologic in its actions.

The pulmonary artery divides and finally terminates in a network of capillaries that form plexuses lying within the walls of the air cells.[1] When the air cells are inflated the capillaries are elongated and their unit volume of blood is increased. On the other hand, if the unit volume of blood is increased, the capillaries are elongated and, as they carry the air cell walls with them, inflation is increased. These actions

1. Miller, W. S.: Key Points in Lung Structure, Radiology **4**:173 (March) 1925.

and reactions also take place in reverse order. The existence of such an air cell-capillary mechanism is disputed; the objections will be answered later. We believe it is the peripheral governor that supplements the controls of breathing and circulatory units by the central nervous system. Dr. E. K. Dunham was the first to note the air cell-capillary coordination, and the mechanism should bear his name. Its actions assure aeration of the volumes of blood required to meet all demands, whether they are at the lowest level, merely to support life, or above this level, to permit ordinary or extraordinary exertions. It is not only effective in meeting the many, wide, suddenly varied and perhaps frequently repeated changes in conditions consequent on rest, activity and disease, but also in acting as a safety valve by preventing pulmonary congestion or edema as well as acute cardiac dilatation.

Dunham's air cell-capillary gear explains how and why vital capacity has been found in the clinic to measure the competence of both the breathing and the circulatory apparatuses and why neither can be much impaired without detriment to the other. Vital capacity likewise indicates the competence of the individual. Competence is the sum of actual and potential energies above those required to support inactive life. Energies are produced by metabolism for which oxidation is prerequisite. Competence is therefore commensurate with abilities to supply oxygen to the body (aeration of blood, external respiration), to deliver it equably throughout the body (effective hematopoiesis, myocardial power and vasomotor control) and to utilize it economically (internal respiration). The reasons why vital capacity measures all steps in oxidation also are clear. If deliveries are persistently unequable or if the internal respiration continues to be faulty, impaired external respiration will ultimately register these defects because the circulatory or respiratory apparatuses will be involved.

Vital capacity, it was noted above, varies with individuals, under different conditions in the same individual, and is higher when competence is greater. Competence is an indicator or a manifestation of reserve power, a corresponding margin of safety that includes resistance, defense and repair. There is a current belief that only intrathoracic diseases reduce vital capacity. It is grounded on a considerable series of reliable observations. Experience of vital capacity estimations, however, is still limited. The technic for making the estimations remains to be standardized. Little or nothing is known of estimations made before and after exertion and how significant they may be. Other tests of external respiration await development.

SIGNIFICANCE IN GENERAL THERAPEUTICS

Vital capacity estimations, suitably controlled, will be significant in general therapeutics should they afford another and perhaps more accu-

rate means to estimate, by measuring oxidizing capacities, the effectiveness of the numerous diverse but coordinated responses that constitute resistance, defense and repair. Vital capacity estimations are particularly significant in intrathoracic surgery, as pointed out by Graham. Diseases involving intrathoracic structures impose in addition to the disabilities caused by similar ailments affecting extrathoracic structures the serious handicap of direct interference with external respiration, the basic function of life, and operations within the chest add materially to these burdens. Vital capacity is an accurate measure of external respiration, and, if it be already considerably reduced by disease, warns against procedures likely to produce further limitations.

Effective external respiration is possible so long as suitable amounts of good blood are propelled without obstruction through the pulmonary capillaries under appropriate pressures and are aerated by the alveolar air. The requirements of the circulatory apparatus are cardiovascular integrity and blood volumes, normal in quantity, quality and in distribution. In the breathing unit the requirements are unrestricted movements of the parietes, normal intrapleural pressures and undiminished pulmonary elasticity. If these conditions are fulfilled, the coordination of the intrathoracic activities of the breathing and circulatory units is automatic through the air cell-capillary gear.

Intrathoracic diseases and injuries cause their peculiar disabilities by impairing the competence, at first more particularly of either the circulatory or the breathing unit, and by involving the other secondarily.

EFFECTS OF INCOMPETENCE

Consideration of the effects of incompetence of the circulatory apparatus can be limited to two phases because anemia and exemia are to a large degree remediable by transfusions of blood and other suitable intravenous medication. Either there is obstruction from incompetence of the left heart or the right heart is unable to develop the power to surmount the peripheral resistance in the pulmonary circuit. The first is chronic passive congestion. The distended capillaries restrict pulmonary elasticity and encroach on the lumen of air cells. The result is reduced vital capacity. The second, pulmonary arterial hypotension, is usually associated with pulmonary compression and with cardiac dilatation. The unit volume of blood in the pulmonary capillaries is decreased and in consequence some deflation is produced. The result is reduced vital capacity. Nature's means to meet these conditions are rest and hypertrophy to develop greater myocardial power; edema and spontaneous hemorrhages to reduce blood volume, and systemic vasomotor influences to alter distributions of the volumes of blood in circulation.

Consideration of the effects of incompetence of the breathing unit can be limited to one phase. Lesions reduce parietal mobility, interfere with intrapleural pressures and decrease pulmonary elasticity. The net result is pulmonary deflation, the phase to be considered. The effect of deflation is reduced vital capacity. Lungs may be affected from without or from within. Extrapulmonary lesions affecting the thorax modify intrapleural pressures. Those causing increments in negative pressures are so infrequent as to be negligible. Increments in intrapleural positive pressures are the rule. They may be so slight as to curtail but not to abolish normal negative pressures. Unit volumes of air and of blood are lessened as negative pressures are diminished. External respiration is correspondingly restricted and the lung assumes positions which for lack of a better term may be called deflation. Should the positive pressures produced by lesions suffice to neutralize the negative intrapleural pressures, the lung is under atmospheric pressure. Unit volumes of air and of blood are further reduced, external respiration is nearly minimal and the lung is in a position of collapse. Pressures in excess of an atmosphere cause still greater reductions in the unit volumes of air and blood, external respiration is soon inhibited and the lung is forced into positions of compression. The terms deflation, collapse and compression define significant differences in position and function, and, although they indicate varying degrees of deflation, they should not be employed inexactly. They are not synonymous and may not be used interchangeably. Intrapulmonary lesions, such as interstitial hemorrhages, tumors and inflammations, exert pressures on adjacent parenchyma with similar effects, i. e., deflation, collapse and compression.

The extent of deflation is determined by the algebraic sum of two sets of forces. On the one side external or internal pressure exerted on the parenchyma plus the elastic recoil of the lung and intermittent slight intratracheal negative pressures act against the blood pressures in the pulmonary and bronchial arteries on the other side, reinforced by the inconstant and slight positive intra-alveolar air pressures and the intrapleural negative pressures if they are unabolished. Consequently, in crises myocardial power, particularly of the right heart, will either suffice to maintain the degrees of inflation needed to provide enough aeration to support life or death is inevitable.

COMPENSATIONS TO OFFSET HANDICAPS

Nature's compensations and adaptations to offset the handicaps imposed by incompetence in the breathing apparatus rest primarily on competence in the circulatory unit and secondarily on pulmonary elasticity. As increasing internal or external pressures act from a focus within a lobe or on an entire lung an orderly sequence in responses is

invoked. Compression of parenchyma, however it be produced, increases pressure on its blood vessels, which raises peripheral resistance within those vessels. Blood in the pulmonary circuit is distributed hydrodynamically. In consequence blood is diverted from the vessels in which peripheral resistance is greater to adjacent vessels wherein it is less, from zones of more to zones of less deflation, collapse or compression. The excess blood thus delivered to the normal or less abnormal lung overdistends its capillaries and causes an amount of inflation or compensatory emphysema which not only maintains the proper relationships between air volume, area of alveolar epithelium, expanse of capillary endothelium and blood volume but attempts to keep their totals nearest to normal. Likewise blood requiring aeration is delivered through walls of alveoli containing necessary amounts of ventilated air. The cost of compensation is increased cardiac labor. Evidences of this compensatory response are exemplified in the margins of emphysema surrounding focal injuries of the lung noted by Gregoire, in the zones surmounting pleural effusions producing the hyperresonance described by Skoda, and in the contralateral emphysema noted by clinicians ever since extensive unilateral intrathoracic lesions have been recognized.

Identical compensations are produced by lobectomies. The emphysema developed in the remaining lung, usually and erroneously called compensatory hypertrophy, then determines the efficacy of external respiration, which is commensurate with vital capacity.

Adaptations occur when there are considerable and rather rapidly produced increments in intrapleural pressures. Extraordinary amounts of blood are needed to effect the compensatory emphysema required immediately to provide adequate, i. e., viable, aeration. These extraordinary amounts of blood, which are projected into active circulation by abrupt pulmonary compression, are provided from the less actively circulating reserve supply that normally is stored in the larger pulmonary vessels. Safety is again obtained at the cost of greater expenditures of cardiac energy, but this time less favorably as sudden demands are met only by expenditures of latent myocardial energies and, because of narrowed margins of safety, these expenditures are the more apt to lead to exhaustion.

Nature strives at all times to maintain the conditions most favorable to external respiration, the competence of which can be estimated by vital capacity. Therapy can do no better than to attempt to cooperate with Nature's methods.

The first and most important requirement is protection of the competence of the lesser circulation, more particularly of the reserve energies in the right myocardium. The second is limitation of pulmonary

deflation and prevention of pulmonary compression, because both interfere with external respiration and both increase the peripheral resistance in the pulmonary circuit, thereby throwing greater burdens on the heart. Abrupt and considerable changes are to be avoided. Moreover, these requirements are to be met in preparation for operation, in operative methods and in postoperative care. Thus may be assured to each patient the largest opportunities for undelayed recoveries with the least danger and the lowest ultimate disability.

CONCLUSIONS

Conclusions from the foregoing are:

Estimations of vital capacity are helpful in diagnosis, in prognosis, in determining the effects of treatment and in measuring ultimate results as they record the effectiveness of the basic function, external respiration.

Protection of the structures and of the activities of the structures that establish and control external respiration so that vital capacity is kept at the highest level permitted by circumstances is the guide to effective treatment of intrathoracic diseases.

Deliveries of blood through bronchial arteries and through the pulmonary arteries are controlled by the functional activities of lungs, which are proportionate to vital capacities.

Resistance, defense, growth and repair of intrathoracic structures, as well as of the entire organism, are commensurate with vital capacity.

Application of the principles suggested in treatment of patients suffering from pleuropulmonary injuries and diseases should lead to more complete recoveries than are otherwise attainable.

PART II

Most clinicians are disinclined to admit the existence and effectiveness of an air cell-capillary mechanism because it has not been described or endorsed by physiologists. Internists have proudly demonstrated skodaic resonance and contralateral emphysema associated with pleuritic effusions and massive consolidations for ages and the edification of their disciples. They have, however, remained serenely unconcerned as to how and why these compensations come to pass, and paradoxically refuse to consider the existence of a life saving device whose actions they themselves have discovered. Some physiologists are unwilling even to consider the possibility of an air cell-capillary gear because its existence was first noted by Dunham who was not a physiologist and because it is foreign to their concepts of the mechanics of external respiration. As a class physiologists have had little bedside experience and have less appreciation of clinical manifestations and problems that are restricted to man. They are loath to credit clinical observations which they hold to be unscientific and perforce undependable unless confirmed by crucial experiments performed on laboratory animals. There are considerable differences of opinion about intrathoracic actions and reactions. Some conceptions are so diametrically opposed that misinterpretations must be largely responsible for the confusion.

Divergent points of view can be reconciled and misunderstandings largely eliminated if fundamental facts, already established, can be recognized, viz.:

1. Estimations of vital capacities are possible only in living human beings.

2. Vital capacities fluctuate with variations in the competence of either the breathing unit or the circulatory unit.

3. Vital capacities measure the competence of external respiration, which depends on the coordinated activities of the breathing and circulatory units.

4. Incompetence of the circulatory unit affects the entire lung and therefore impairs the competence of the whole breathing unit.

5. Incompetence of the breathing unit at first, local or focal, affects the circulatory unit without noticeably impairing its competence, and, until the circulatory unit becomes incompetent, the uninvolved breathing unit continues its activities.

6. Incompetence of the circulatory unit is more serious than incompetence of the breathing unit as it assures greater interference with external respiration.

7. Activities of the circulatory unit are essential to the maintenance of inflation needed in external respiration.

8. Temporary obstruction of the pulmonary artery is followed by atelectasis in the corresponding part of the lung, and permanent obstruction in thick pleuraled animals leads to contraction and cicatrization of that part, possibly of the entire lobe.

9. The breathing unit can provide little of compensation or of adaptation to offset incompetence of the circulatory unit.

10. A circulatory unit, so long as it is relatively competent, can provide effective compensations and adaptations to offset incompetence of the breathing unit.

11. Incompetence of the breathing unit is in the main produced by pressures exerted locally on or focally within the lung.

12. Deductions from observations made on the effects of pressures exerted experimentally on or within the lung must, if they are to be applied to man, be suitably interpreted.

13. Competence or incompetence of the circulatory unit must be established when observations are being made and their influences must be duly recognized.

14. Man has a thick pleura, and if animals with thin pleurae are employed experimentally the inherent differences have to be considered.

15. Animals having thick pleurae differ from those having thin pleurae as follows: (*a*) Septums are present in the lungs of thick pleuraled animals and absent in the lungs of thin pleuraled animals. (*b*) The visceral pleurae of thick pleuraled animals are supplied with blood from the bronchial artery and the visceral pleurae of thin pleuraled animals receive a blood supply from the pulmonary artery which carries but one-sixth the pressure of the bronchial artery. (*c*) The pleurae and mediastina of thick pleuraled animals are less flexible and are impermeable to water and to air; those of thin pleuraled animals are more flexible and are immediately permeable to water and slowly permeable to air.

16. Observations on the effects of pressures exerted on or within lungs are at most of only negative value in reference to vital capacity if conducted on cadavers, however fresh, because the centrifugal pressures exerted by the circulatory unit are eliminated.

17. Similar observations on animals of one type of pleura are only indirectly applicable to those of the other type because they differ physically and physiologically.

Clinical and experimental observations were presented before a meeting of this association in 1921 that illustrated occurrences when pressures on lungs of animals of thick and of thin pleurae resulted from artificial pneumothorax induced by injecting air into one pleural cavity. Two sets of conditions were discussed. Pneumothorax was induced abruptly and carried to high positive pressures or created gradually and less pressure exerted. The circulatory unit was competent or incompetent commensurate with myocardial fatigue.

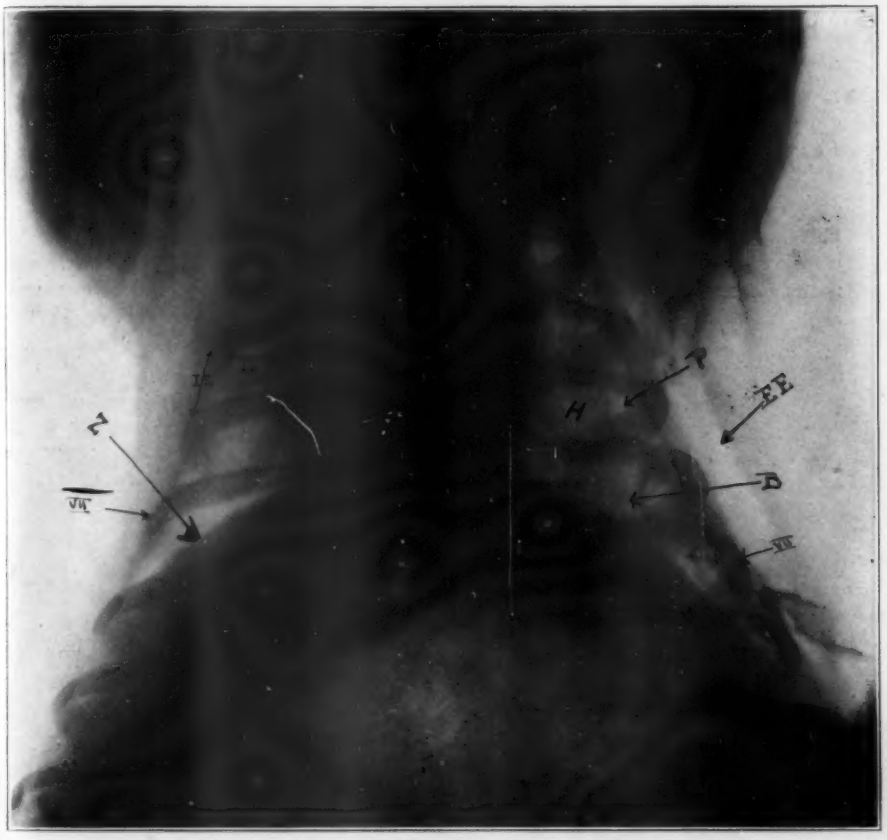

Fig. 1 (Observation 1).—Chest of Sheep 1; *B*, balloon; *P*, pneumothorax; *EE*, extrathoracic emphysema; *VII*, seventh rib; *D*, distance between right cardiac margin and adjacent parietal pleura; *IS*, width of interspace between fifth and sixth ribs; *H*, homolateral emphysema, the less density here is attributable in part to pneumothorax; *Z*, zone of emphysema to be seen just above diaphragm during inspiration—if the lung is approximately normal, the presence of this zone indicates inspiration and its absence, expiration.

When pneumothorax is produced by injecting air into one pleural cavity in animals with thin pleurae (dogs), the intrapleural pressures of both sides vary similarly and simultaneously. It is noteworthy that the variations in pressure in the contralateral side frequently exceed those in the side wherein the pneumothorax is created.

Protection against inevitable deflation and impairment of external respiration is provided by rises in blood pressures. If the pressures on the lung are gradually increased, and if the circulatory unit is competent, respirations can continue even after the intrapleural pressures become positive bilaterally and will continue until the heart muscle can no longer produce the required compensatory pressures. Then the centripetal pressures on the lung caused by the positive intrapleural pressure exceed the centrifugal pressures within the lung provided by the blood pressures, and the consequent deflation is incompatible with effective external respiration.

The more competent the circulatory unit the higher the centripetal pressures of increasing pneumothorax that can be met and the longer adaptative hypertension can be maintained. If the pressures on the lung develop abruptly, the circulatory unit can provide adaptative hypertensions for less pressures and for shorter intervals.

Striking differences were noted when air was injected into one pleural cavity of animals with thick pleurae (monkey). At the time the pressures of the pneumothorax equalled the atmospheric pressure the negative intrapleural pressures in the opposite side had been reduced one-half and respirations were not embarrassed. Later when the positive pressure of the pneumothorax was about five times the normal negative pressure, the negative pressures in the contralateral side had been reduced to one-fourth and respirations were only slightly embarrassed.

When, however, the same experiments were performed on monkeys suffering from myocardial fatigue, the responses were comparable to those obtained when dogs were employed. Contralateral negative pressures were maintained for short intervals and then positive pressures developed abruptly perhaps in excess of those on the side of the pneumothorax.

Again it was found that respirations could continue temporarily in the presence of slight bilateral positive intrapleural pressures, and this interval was determined by abilities to sustain a compensatory rise in blood pressures. Moreover, it was noted that when the positive pressures created by the pneumothorax were eliminated by aspirations of the pneumothorax negative pressures returned. If the positive pressures had been high, the succeeding negative pressures were greater than normal for short intervals and then returned to normal.

All of these experiments and their controls were conducted under fairly deep anesthesia from ether administered by the open drop method. Thus, the significant variables were the pressures exerted by fluctuations in the degrees of artificial pneumothorax, the competence of the circulatory unit manifested in myocardial power, and the inherent differences between animals of thick and those of thin pleurae.

Compensations and adaptations were registered by systemic blood pressures on a mercury manometer and by intrapleural pressures on bromoform manometers. Presumably the pressures in the pulmonary circuit fluctuated with those in the systemic. All variations in intrapleural pressures not directly attributable to the pneumothorax (as if the pneumothorax had been produced in a cadaver) are therefore to be traced to variations in the unit volumes of blood delivered to the lung and to variations in the distribution of those fluctuating amounts of blood.

Pneumothorax created in dogs and in fatigued monkeys causes greater positive intrapleural pressures to appear on the opposite side. After the pneumothorax is withdrawn, negative pressures in excess of normal are temporarily developed.

These manifestations are explicable. Lungs overfilled with blood are more densely voluminous. (There is less effective compensatory emphysema under such conditions.) More voluminous lungs incur less negative or greater positive

Fig. 2 (Observation 1).—Chest of Sheep 1 during expiration; the diaphragm is one interspace lower; the heart is farther from adjacent parieties (*D*); and the width of the fifth to sixth interspace is greater; homolateral (*H, H, H*) and contralateral (*C*) emphysema have developed.

intrapleural pressures than normal. Conversely, lungs underfilled with blood are less voluminous and incur more negative or less positive intrapleural pressures than normal. The observations noted above are confirmatory, particularly the occurrence of increased negative intrapleural pressures after the lungs have

been compressed and the reserve blood expressed. The final substantiation is the return of normal intrapleural pressures as soon as normal circulation is readjusted.

It has been proved that man and monkey, if their circulatory units are competent, can withstand an open pneumothorax produced abruptly by wide opening of chest walls, whereas dogs and man or monkey having incompetent circulatory units can withstand open pneumothorax only when produced gradually, if at all.

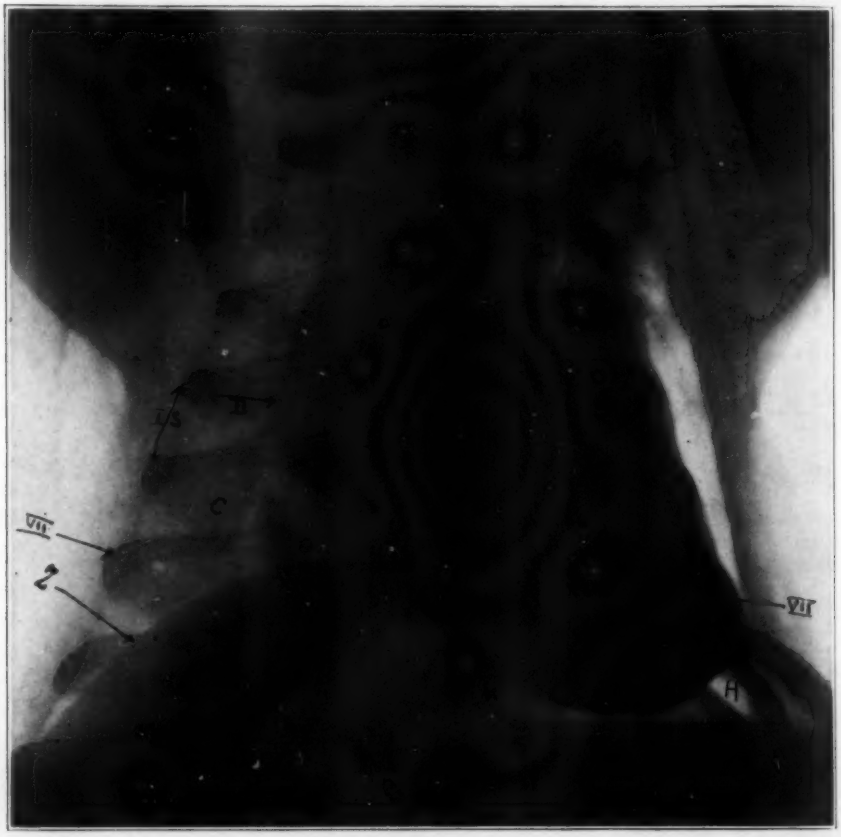

Fig. 3 (Observation 1).—Chest of Sheep 1 during inspiration, shown by supradiaphragmatic zone of emphysema (*Z*); homolateral (*H, H, H*) and contralateral (*C*) emphysema still present; approaching decompensation indicated by displacement of heart (*D*) to the right; in Figure 2 it had been displaced toward the left.

The explanation is simple. Pulmonary deflation provoked by pneumothorax diverts blood from the lung first affected to the opposite lung. In animals with thick pleurae this excess blood increases inflation sufficiently in the contralateral lung to maintain effective external respiration provided the myocardium can develop the excess power required to deliver greater unit volumes of blood to one lung instead of to two and against higher peripheral resistance.

In animals with thin pleurae the same shunting of blood occurs but the inflation produced in the contralateral lung is inadequate to develop and to maintain the increment in inflation requisite for effective external respiration. This failure has been charged to greater mobility of the mediastina in thin pleuraled animals, a factor of minor significance. We held, erroneously, that it was because the mediastinum in a thin pleuraled animal is not air-tight, which it is for a brief period. The more important factors are the differences in pleural and lung structure and the variations in blood supply. Deliveries of blood through pulmonary arteries in thin pleuraled animals that supply the visceral pleura are apparently less effective in developing and in maintaining inflation than through pulmonary arteries in thick pleuraled animals in which the visceral pleura receives its blood from the bronchial arteries. When the circulatory unit of a thick pleuraled animal is incompetent, this ability to produce contralateral inflation is reduced, and in effect the results of increased unilateral intrathoracic hypertension are the same as in the thin pleuraled variety. At any rate the capacity to develop increased inflation in less affected lung to compensate for deflation in the more affected lung depends on the influence of the circulation and is less in the thin pleuraled animals than in the thick. It is notably decreased in both as incompetence in the circulatory unit (myocardial fatigue) advances.

Experiments have been performed to provide visible evidence if there be productions of compensatory emphysema. Small rubber balloons were inserted by means of trocars and cannulas between the lower lobes of the left lungs and the diaphragms of a sheep and a dog. The procedure is easy with the aid of a fluoroscope. Roentgenography and roentgenograms, taken at intervals, were employed to follow the reactions as the balloons were filled and emptied at will by raising and lowering a gravity bottle containing water and barium to give a sharp outline between lung and balloon. Open ether anesthesia was used.

PROTOCOLS

Observation 1.—Although precautions were taken to prevent causing pneumothorax while a balloon was being inserted, they were incompletely successful. Figure 1 shows the collapsed balloon in position between the lower lobe of the left lung and the diaphragm of Sheep 1. A slight amount of intrathoracic pneumothorax and of extrathoracic emphysema had resulted. The heart had apparently been dislocated toward the opposite (right) side, but this appearance might be due to the position of the animal. The levels of the two sides of the diaphragm and the amount of intragastric air should be noted. As the balloon was filled with barium water by elevating the gravity bottle, emphysema was seen to appear in the lung about the bag and almost at once in the contralateral lung. At no time was it possible to recognize a zone of more compact lung adjacent to the bag. Either this did not occur and our conceptions of the actions of an air cell-capillary gear are erroneous or the zones of compression were not demonstrated with the means employed. When the balloon had been moderately distended, the animal, which was not robust, exhibited no gross manifestations of respiratory or circulatory distress. A margin of emphysema (Fig. 2) surrounded the balloon, affecting the lung above, below and lateral to the bag. Contralateral emphysema was unmistakable and sufficient to dislocate the mediastinum back toward the side of initial compression. This expansile power, the

centrifugal force of the circulation, had also depressed the level of the right diaphragm, which was approximately (in the picture at least) one interspace lower than on the previous roentgenogram. Another confirmation of the action of expansile force was found in the wider intercostal spaces. Slightly greater distention of the balloon (Fig. 3) produced correspondingly greater degrees of homolateral emphysema. The contralateral expansile force was less effective and the mediastinum was being dislocated away from the side of compression.

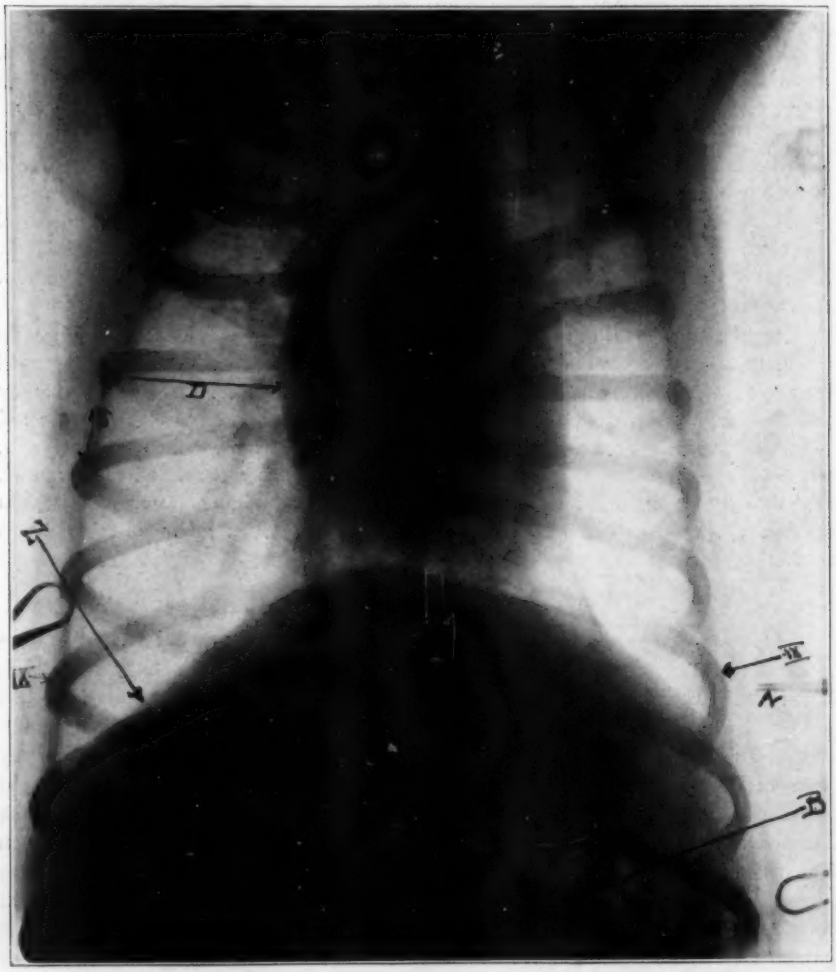

Fig. 4 (Observation 3).—Chest of Dog 1 before insertion of balloon; supradiaphragmatic zone of emphysema (*Z*) shows roentgenogram to have been taken during inspiration; *IX-IX*, ninth ribs, on left just above (*N*) the site of insertion of balloon; *IS*, width of sixth to seventh interspace; *D*, distance between right margin of heart and adjacent parietal pleura; *B*, barium in gastro-intestinal canal, remnant of previous observation and of no significance.

Further distention led to decompensation and dyspnea with increasing displacement of the mediastinum toward the opposite side. Allowing the barium water to escape from the balloon by lowering the gravity bottle produced a similar series of changes in reverse order.

Fig. 5 (Observation 3).—Chest of Dog 1 during expiration; homolateral (*H, H, H*) and contralateral (*C*) emphysema present; heart displaced toward left (*D*); width of interspace (*IS*) not materially altered; diaphragm pushed downward about one interspace; *B*, barium in gastro-intestinal tract.

Observation 2.—A catheter was introduced intercostally on the right side in Sheep 1. Through it barium water was made to enter the free pleural cavity. Effects quite identical with those recorded in Experiment 1 were produced.

Observation 3.—A balloon was employed in Dog 1. Figure 4 shows the chest before the balloon was inserted. After the balloon had been moderately

distended the mediastinum was again displaced toward (Fig. 5) the side compressed. Later when the bag was more distended the mediastinum was displaced away from the side compressed (Fig. 6). Similar changes in reverse order were noted as the barium water was gradually withdrawn from the bag.

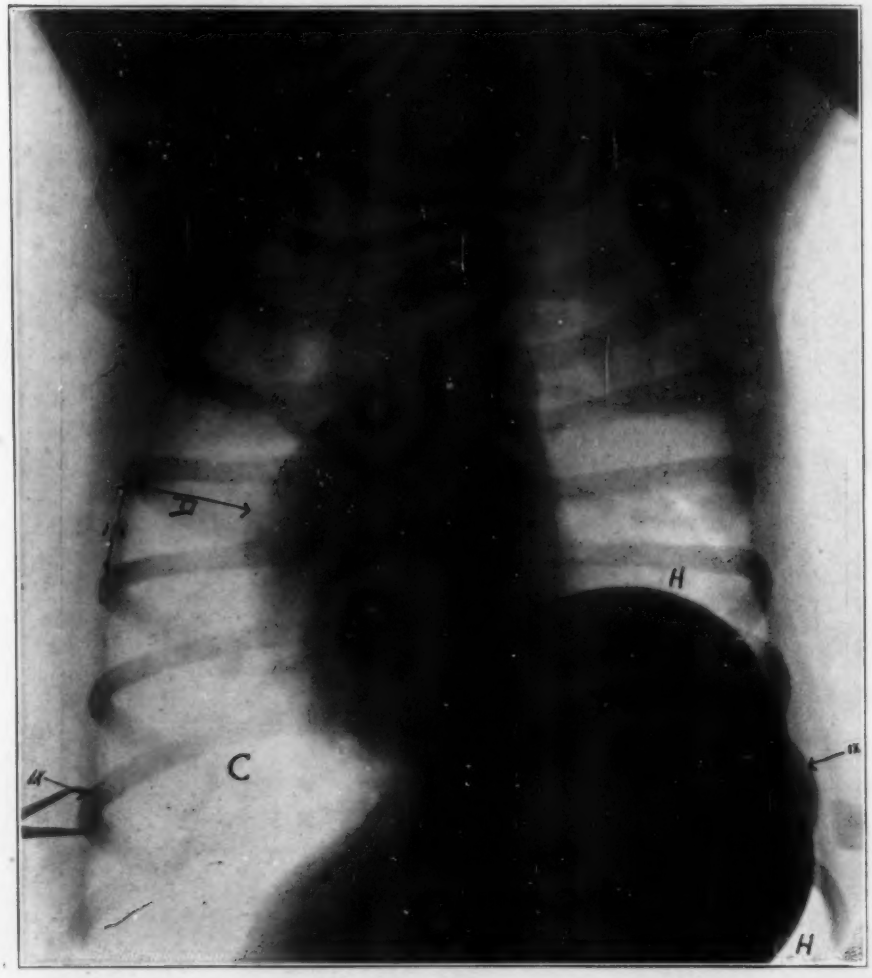

Fig. 6 (Observation 3).—Chest of Dog 1 during expiration; homolateral (*H, H*) and contralateral (*C*) emphysema present; compensation beginning to fail, shown by displacement of heart (*D*) toward right, though diaphragm is still forced downward.

CONTROL OBSERVATIONS

Roentgenographic studies were made during the course of spontaneous pneumonia in a man. Figure 7 (taken April 20) shows consolidation within the right lower lobe. The physical signs and symptoms then present indicated pleuritis. Absence of effusion and the contractions of the diaphragm on the

affected side proved the absence of pleurisy. Irregularity of contraction, seen in the depression of the midportion of the right diaphragm and absent in the rounded contour of the left segment, showed that contractions were spasmodic. Homolateral and contralateral emphysema were present. Contralateral emphy-

Fig. 7 (Observation 4).—Appearance of chest in spontaneous pneumonia in a man, April 20, 1925; consolidation in right lower lobe sufficient to push the right diaphragm downward and to provoke homolateral and contralateral compensatory emphysema.

sema sufficed to prevent displacement of the mediastinum to the left and homolateral emphysema had depressed the right diaphragm at least one interspace. Four days later (Fig. 8, taken April 24) resolution had so progressed that decreased internal compression had caused less homolateral and contralateral

emphysema and less depression of the right diaphragm. A week later (Fig. 9, taken April 27) resolution was almost complete and the diaphragm was regaining its normal position and symmetrical contraction, though still slightly spasmodic at the end of forced inspiration when this picture was taken. This

Fig. 8 (Observation 4).—Appearance of chest, May 24; resolution progressing; displacement of right diaphragm and amount of compensatory emphysema are less.

indicates that pulmonary elasticity had not been restored and inspiration was abnormally burdensome. A fluoroscopic examination made July 3 found the diaphragmatic action to be similarly though less impaired. The patient's vital capacity was only 97 per cent., although his weight was subnormal. The delay in rehabilitation of the normal contraction of the diaphragm, which is the most effective factor in mobility of thoracic parietes, illustrates nicely

the wisdom of insisting on continuation of breathing and general exercises after the acute phases of pleurisy and pneumonia have subsided and until normal conditions are reestablished. Pryor showed that pleurisy caused the diaphragm to take an abnormally high position, which was prone to persist. Middleton found that just disability ratings were proportionate to reductions in vital

Fig. 9 (Observation 4).—Appearance of chest, showing resolution farther advanced; diaphragm regaining its normal position, though still depressed; the roentgenogram, taken during inspiration, shows spasmodic contraction of right diaphragm; compensatory emphysema has virtually disappeared.

capacity, which in turn were commensurate with abnormalities in positions and limitations in the range of contractions of the diaphragm. The sole means to restore the functions which determine the integrity of the breathing unit, namely, unrestricted parietal mobility, normal intrapleural negative pressures and pulmonary elasticity, is through persistent active motion.

CONCLUSIONS

Compensatory emphysema occurs with internal or external pulmonary deflation, collapse and compression, whether they are developed gradually and spontaneously or provoked abruptly and experimentally, provided the circulatory apparatus is relatively competent.

Compensatory emphysema is a purposeful biologic response to pulmonary deflation, collapse and compression, which provides margins of safety in external respiration.

The breathing apparatus is a passive agent in the production of compensatory emphysema.

The circulatory apparatus is the active agent not only in producing compensatory emphysema when there is deflation, collapse or compression, but also in maintaining the degrees of inflation during periods of rest and of physiologic emphysema during periods of activity which are optimal for external respiration.

An air-cell capillary gear intermeshing with the breathing and the circulatory mechanisms is the means whereby the active agent, the circulatory unit, maintains the degrees of inflation in the passive breathing unit essential to external respiration under normal conditions and develops requisite compensatory emphysema to safeguard external respiration in the presence of pulmonary deflation, collapse and compression.

The chief therapeutic obligation in combating intrathoracic diseases is to protect the circulatory unit because protection entails relief of lesions in the breathing unit.

COMMENT

Previous presentations of the physiologic interrelationships of the breathing and the circulatory apparatuses with particular reference to clinical problems have been criticized for being devoid of practical value. The proof of the pudding is in the eating.

Our attempts to employ methods that cooperate with natural processes concerned in resistance, defense and repair have contributed to the achievement of higher degrees of ultimate recoveries than are otherwise attainable. We can make no claims for superior skill. We do make positive claims for the greater efficacy of procedures based on physiologic requirements. A few examples will be cited in evidence.

Through the aid of the surgeon-general, Dr. W. S. Middleton was enabled to make personal examinations of many of sixty-four soldiers three years after they had been treated for thoracic wounds. He also was given access to official records so that a dependable estimate of the status of the entire series was possible. Middleton found that the average ultimate disability rating was approximately one third of the disability allowance for soldiers treated in this country for empyema. A

small number had received minor injuries, but many had undergone multiple rib resections and some had been subjected to resections of lung segments. None received any after-care, such as the breathing exercises essential to restore pulmonary elasticity, reestablish intrapleural negative pressures and recover parietal mobility. A fair proportion suffered from empyema, which was treated in the orthodox manner. Hence, the primary treatment had been effective.

The main problem in treating thoracic wounds is the prevention of purulent pleuritis. The same principles that determine prevention of traumatic suppurative pleuritis apply in the prevention and treatment of the spontaneous varieties, namely, to maintain the apposition of visceral and parietal pleurae and employ breathing exercises to restore parietal mobility and pulmonary elasticity. Patients with tuberculous pleurisy and even that due to malign tumors can be induced to recover. Similarly, the acute forms, particularly in early stages, respond to air-tight intercostal catheter drainage, which can also be used effectively in the relief of interlobar types and of intrapulmonary abscesses. The chronic forms, notwithstanding thick, organized exudates, need not always require mutilating operations to recover. Use of an aqueous solution of chlorinated soda (Dakin) and of an alcoholic solution of gentian violet as advocated by Keller, coupled with suitable breathing exercises, can lead to recoveries with vital capacities returned to normal or even raised above normal.

I have the privilege of working in cooperation with the staff and administration board of the Muirdale Sanitarium for Tuberculosis of Milwaukee County. It has been found that minor operations designed to influence intrapulmonary circulation, and particularly to protect heart muscle, are feasible. Simpler operations, if employed earlier, as adjuncts to other measures not only obviate the more formidable procedures, such as extensive thoracoplasties, but hasten more complete recoveries.

Hence our contention that acute and chronic intrathoracic diseases and recent thoracic injuries can be treated more simply and safely by measures that will conserve external respiration by keeping vital capacities high during active phases of maladies and leave them, after convalescence, at their peak.

DISCUSSION

DR. FRANCIS W. PEABODY, Boston: My experience with the determinations of the vital capacity of the lungs has been largely limited to its relation to medical conditions, and it is extremely interesting to me to find that surgeons also are beginning to regard the test as of value. In the last few years those who have been studying the function of the respiration have devoted their attention largely to the changes in the blood gases and have paid little attention to the mechanical aspect of pulmonary ventilation. Variations in the gaseous content of the blood are of course of the utmost importance, and they affect the stimulus to respiration; but at the same time one cannot neglect the response

on the part of the lungs to this stimulus. This response manifests itself in the ventilatory function of the lungs which promotes the proper exchange of gases through the cells of the alveoli.

The determination of the vital capacity of the lungs gives one an indication of the functional capacity of one phase of respiration—of the ventilatory function. Even slight decreases in the ventilatory function of the lungs may be determined, and in this way the test is to some extent more delicate than certain other functional tests in common clinical use. Thus, for instance, tests of renal or hepatic function do not indicate any abnormality until perhaps three fourths of the organ under investigation is thrown out of commission.

There are several points that are often raised in objection to the clinical value of the determination of vital capacity. The first is that the test is subjective and not objective in character. It depends on the cooperation of the patient and on his making a maximum effort. This is, of course, a certain disadvantage. It is, however, more a theoretical disadvantage than a practical one because it is almost always possible to determine whether a patient is making a maximum effort or not; when he is not the observation can be discarded. In general, one should have few misleading results.

The second criticism is that there is a considerable variation in normal values. Normal values vary for different age periods, and even in the period between 18 and 45 years, during which there is little change in the vital capacity, one must accept the fact that individual variations run from 5 to 10, or possibly 15 per cent. above and below the average standard values. This is a difficulty that one can meet only by realizing the normal variations. Other clinical tests, such as the leukocyte count, also have considerable variations within the normal limits, but these variations do not militate against the practical value of the tests.

The third criticism to the practical value of the determination of the vital capacity of the lungs is that variations in vital capacity do not have any specific significance. They merely indicate that a definite function of the lungs is interfered with and one must then determine from physical examination and from other methods of examination to what this abnormality is due. This lack of specificity is, however, not very important for it is inherent in a great many methods of examination in constant use. Most clinical tests are not specific but merely help one to localize a pathologic process and increase the accuracy with which one can make a diagnosis.

In medicine, the determination of the vital capacity of the lungs has been most useful in the field of cardiac disease. It is less valuable in diagnosis than it is in prognosis, and it is of particular interest in following the course of cases from day to day and from week to week. The graphic record of the vital capacity of the lungs in a case of chronic heart disease usually gives one a better idea of the clinical course of the case than do any of the other observations that are made. In the field of tuberculosis considerable interest has been manifested in the test, but it does not seem probable that it will be so important as in the field of heart disease.

It has been very interesting to me, after having been concerned with the problem for a number of years, to find that it is now beginning to work its way into the field of thoracic surgery.

Dr. Edward D. Churchill, Boston: In an experimental study of the relation between the distribution of air and of blood in the lungs we have devised the following method in Dr. Cecil Drinker's laboratory: A cat, anesthetized by intravenous barbital sodium, is temporarily given artificial respiration while an oval window is made in the anterior chest wall by resection of the sternum.

A ligature is then placed around the left primary bronchus, and one of a pair of metal tubes, which up to this point have been utilized in maintaining the artificial respiration through tracheotomy opening, is passed into this left bronchus and secured by tying the ligature. This enables us at a later stage of the experiment to collect the air from each lung in separate spirometers by means of delicately balanced valves inserted in each airway.

The pericardium is then opened by a median incision and its edges sutured to the margins of the window in the chest, forming an air-tight connection after the manner previously described by Drinker. The air in the pleural cavity is now aspirated and the positive pressure ventilation is discontinued. The animal resumes its natural breathing. The complete removal of air from the pleural cavity is insured by lifting the heart and inspecting the lungs through the transparent pericardium.

An animal prepared in this manner will breathe normally and maintain a normal blood pressure for a period of hours. Ligatures may now be placed about any of the great vessels as they enter or leave the heart and their occlusion and subsequent release effected by traction with a specially devised clamp.

After two control collections of minute volumes of tidal air the right pulmonary artery is clamped; the total ventilation is immediately increased from 850 to 1,600 c.c. by more rapid and deeper respirations. This increase is, however, shared proportionally by the two lungs. Although the right lung is receiving no blood from the pulmonary artery, the amount of air it moves has actually been increased by at least 50 per cent., and in direct ratio to the increase in ventilation of the left lung, which at this time is receiving all the blood of the lesser circulation. On release of the clamp the original condition is restored.

As a check on the mechanism of the preparation the function of the right lung may be suspended by closure of the airway. Again the animal increases the ventilation of the left lung which in both procedures is the only effective respiratory unit.

In clamping the left pulmonary veins we have found this interesting development: The increase in total ventilation is not as marked but it is relatively more in the lung in which the congestion is produced. Further, the increase of the ventilation of the left lung seems to be progressive and always at the expense of the volume of air moved by the right.

Turning now to a similarly prolonged clamping of the right pulmonary artery over a period of minutes, we again see that the relative ventilation of the lung that has the greater blood supply seems to show a slow increase. As would be expected this is in a less degree than shown previously in the experiment with vein compression.

These results at first sight seem to contradict the previous experiments reported from Drinker's laboratory, in which pulmonary vein compression caused less air to enter the lungs of an artificially ventilated animal. In those experiments, however, the pulmonary veins to both lungs were compressed and the total ventilation measured. Here we are dealing with compression of the veins to one lung only and with separate collections of air. In other words, although this work is still in progress, our results to date would indicate that while it is probably impossible beyond certain narrow limits simultaneously to increase the blood and the air content of the chest as a whole, there may be some mechanism such as Dr. Yates has postulated which maintains an equilibrium between the volumes of blood and of air in a given portion of the lung. This would only function, however, by a corresponding encroachment on the volume of adjacent areas.

DR. EVARTS A. GRAHAM, St. Louis: To the thoracic surgeon a consideration of the vital capacity is of particular importance because it concerns methods of intrathoracic procedure and their results on the patient. As Yates has already stated in his part of this symposium, the vital capacity is an indication of the competence of the mechanism of external respiration. The effect of various intrathoracic procedures on this mechanism is to some extent dependent on the vital capacity.

In 1918 Bell and I (Graham, E. A., and Bell, R. D.: Open Pneumothorax: Its Relation to the Treatment of Empyema, Am. J. M. Sc. **156**:839 [Dec.] 1918) showed that the size of an opening in the chest wall which is compatible with life, if the mediastinum is not stabilized by adhesions or induration, is largely determined by the vital capacity of the individual. Likewise the effects of a closed or of an artificial pneumothorax are largely determined by the vital capacity if no adhesions are present. These points have been further developed in a series of articles by me (The Importance of the Vital Capacity in Thoracic Surgery, J. A. M. A. **75**:992 [Oct. 9] 1920; A Reconsideration of the Question of the Effects of an Open Pneumothorax, Arch. Surg. **8**:345 [Jan.] 1924; Principes qui découlent de la chirurgie intrathoracique, Presse méd. **31**:141 [Feb. 14] 1923; Recent Phases of Thoracic Surgery, J. A. M. A. **80**:1825 [June 23] 1923). It will be unnecessary to repeat the argument here in detail except to state that it is dependent on the fundamental fact that, in the normal thorax, any alteration of intrapleural pressure on one side affects not only the lung of the corresponding side but also that on the opposite side. Pressure effects, therefore, are not confined to one lung but concern both lungs. These pressure effects are about equal on the two lungs when a slight alteration of intrapleural pressure occurs on one side; although not equal when an excessive pressure occurs, nevertheless both lungs are affected. Compression of both lungs obviously interferes with the accomplishment of respiration both by diminishing their breathing surface as well as by diminishing the amount of blood passing through them. It becomes apparent at once then that if a patient's vital capacity is low, he will be able to withstand less compression or less additional compression of his lungs than if his vital capacity were high. When an opening is made in the chest wall on one side, the amount of compression of the lungs from the open pneumothorax will depend, up to a certain extent, very largely on the size of the opening because it will depend on the amount of air which passes in at each inspiration through the opening. Contrary to the usual belief, equilibrium at atmospheric pressure does not occur when only a small opening in the chest wall is present, for the reason that the thorax is constantly changing its size. Rapid changes in size of any structure are accompanied by changes in the pressure of the contained gas. For all these reasons, therefore, a person with a low vital capacity cannot withstand an opening in the chest wall so large as a person with a normal or a high vital capacity, provided in both cases that the thorax is normal in the sense that there are no adhesions or abnormal thickening of the mediastinal pleura.

Duval's contention (Les donnees actuelles de la chirurgie intrathoracique unilaterale en plevre libre, Presse méd. **30**:409 [May 13] 1922) that a large pleural opening is tolerated better than a smaller one has been answered in a recently published article by me (Alterations of Intrapleural Pressure and Their Significance, Medicine **3**:417, 1924; also in Harvey Lectures for 1924) in which it was shown that all the experimental evidence both of our own and of others except Duval indicates that the reverse is true, and that he apparently wrongly interpreted the shallow respiration from anoxemia in his cases of large pleural openings as being an advantageous rather than a disadvantageous result. In opposition to Duval's contention, it is clearly evident that, other things being

equal, the larger the opening the greater the danger to life. These points, as well as other criticisms of our ideas, have been fully discussed in my article to which reference has just been made. They will not be considered in detail here.

The importance of these considerations is seen when they are applied to practical surgical problems. Thus, for example, in acute empyema it is now generally admitted that open drainage of serous or serofibrinous exudates is bad surgical practice. The strikingly lower mortality which has been everywhere observed when open drainage has not been performed too early may not have been entirely due to the avoidance of an open pneumothorax, yet the evidence seems overwhelming that this principle was one of the most important factors, if not the most, in the remarkable reduction of the mortality from streptococcal empyema which occurred during the war as soon as this principle was recognized. For, in the majority of cases, the serous and serofibrinous exudates were present at the same time when the vital capacity was greatly reduced because of the presence of active pneumonia and before sufficient adhesions had been formed to stabilize the mediastinum and to minimize the serious pressure effects of the open pneumothorax. In any case of empyema, if open drainage is withheld until after the exudate has become frank pus, then one not only drains an abscess walled off by adhesions instead of an inflammation in the preabscess stage often involving the whole pleural cavity, but he also minimizes pressure disturbances by allowing the active pneumonia to subside somewhat, thereby permitting the vital capacity to increase.

Although these considerations had perhaps their most striking demonstration during the epidemic of empyema during the war, yet they hold equally well in the case of any opening in the chest wall, whether it is made by the surgeon or occurs as the result of a penetrating injury. Unless the medastinum is stabilized by adhesions or by inflammatory thickening, a large pleural incision will be badly tolerated by a patient with a low vital capacity, and if the incision is too large death may occur from asphyxia. Likewise in other therapeutic procedures, such as artificial pneumothorax and thoracoplasty, for example, the same considerations hold good. Some deaths that have been ascribed to air embolism after artificial pneumothorax might with equal justice in my opinion be ascribed merely to the serious pressure disturbances occasioned by the action of the pneumothorax on both lungs in persons who happened to have low vital capacities. Similarly, in thoracoplasty the wisdom of a two stage operation becomes readily apparent, because the danger of a sudden compression of the opposite lung is thereby minimized.

It is not necessary in all surgical chest cases that the vital capacity should be measured as a preliminary to the operation; yet the simple precaution of actually knowing its measurement is wise. Even in cases in which an artificial pneumothorax is to be performed a knowledge of the vital capacity may serve as a warning against using too much air. In cases in which an incision is to be made into the chest, a low vital capacity will certainly indicate more urgently the presence of suitable apparatus for the inflation of the lungs if necessary. In our own work, Singer and I measure the vital capacity in practically all cases.

The conception of Yates of an air-cell capillary mechanism is a brilliant one. Dr. Churchill's work also is precise and careful. It is quite obvious that much more careful experimental work will have to be done before we can be sure of the truth of Yates' hypothesis. Certain facts that seem to me to argue against it have already been mentioned in one of my former articles (Medicine **3**:417, 1924). If a distention of the capillaries results in an elongation and enlargement of the alveoli, as assumed by him, then this should become apparent

if the capillaries are experimentally distended. As a matter of fact, however, Davis and I have found that distention of the capillaries is actually accompanied by a diminution of the alveoli. Conversely also, Chillingworth and Hopkins (Physiologic Changes Produced by Variations in Lung Distention, II, Efficiency of the Pulmonary Circulation in Overcoming Obstruction, Am. J. Physiol. **51**:289

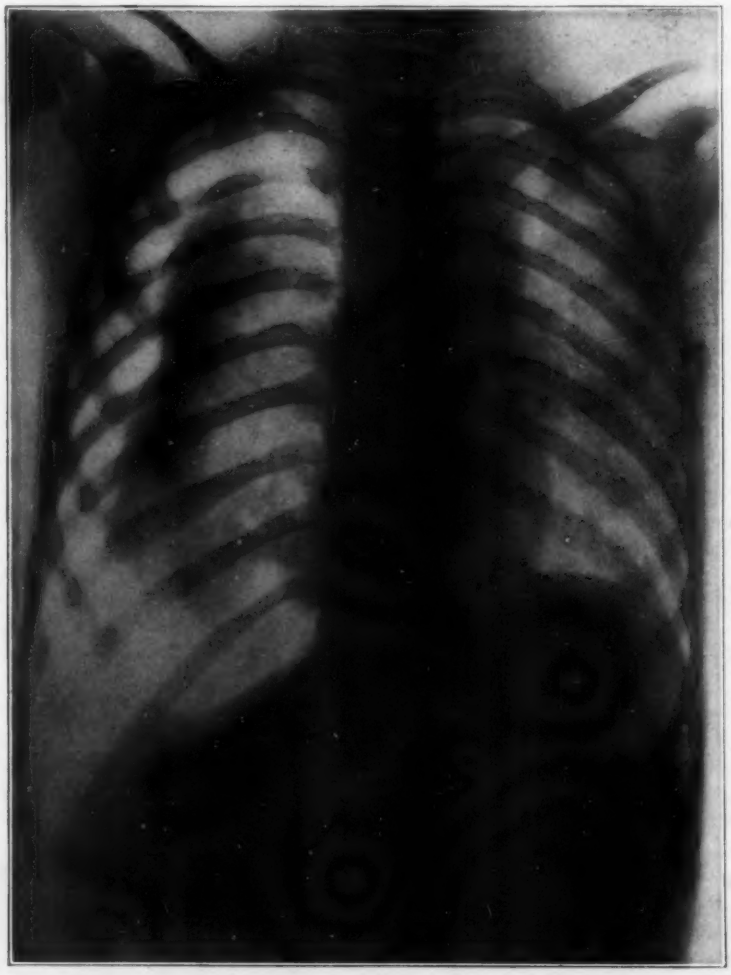

Fig. 10.—Spontaneous left pneumothorax in a child without penetrating injury, showing extreme displacement of heart into right side of chest accompanied by extreme dyspnea; measurement of the pressure of the contained air showed a reading equal to that of only 6 cm. of water; this amount of pressure is only about one twentieth of the systemic blood pressure and yet it is capable of producing very serious symptoms.

[March] 1920) found that by placing dogs in a specially devised body plethysmograph moderate distention of the alveoli was accompanied by a fall in the carotid pressure and that with full distention the carotid pressure fell approxi-

mately to zero. They considered that the fall of carotid pressure is due to failure in the supply of blood to the left heart, a failure which is due to pressure exerted almost directly on the small pulmonary vessels.

For these reasons, therefore, it would seem to me that the evidence is against the hypothesis of Yates, although further work may show that it is correct.

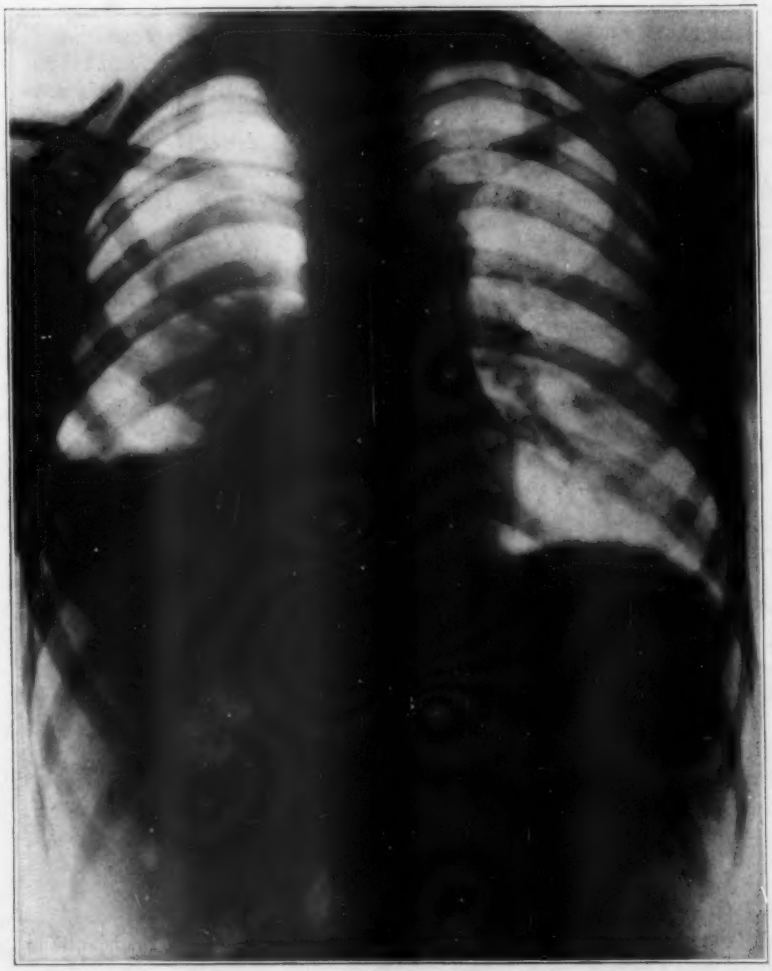

Fig. 11.—Appearance of chest of child in Figure 11 after the aspiration of 100 c.c. of air when the heart came back approximately into the normal position and the extreme symptoms were completely relieved; the child made an uneventful recovery. The roentgenogram taken the next day also showed the accumulation of fluid, which is a frequent result of pneumothorax.

In a recent article (Medicine **3**:417, 1924) I have shown that only slight alterations of pressure in one pleural cavity are sufficient to produce marked disturbances in both pleural cavities provided there are no adhesions or no induration of the mediastinal pleura. In this connection I should like to present

some roentgenograms (Figs. 10 and 11) of a child who had a spontaneous pneumothorax on the left side resulting from being bumped by an automobile truck. The accident had undoubtedly caused a laceration of the lung although there was no open wound communicating with the outside. In Figure 1 it is readily apparent that the heart is entirely on the right side and that the trachea is likewise displaced. The child was in an alarming condition because of extreme asphyxia; however, the amount of pressure of the contained air was found to be equal to only 6 cm. of water, a very slight amount of pressure which when translated into terms of mercury amounts to only about 5 mm. When one compares this slight pressure with the systemic blood pressure, which is more than twenty times as great, it becomes readily apparent that only very slight alterations of intrapleural pressure are sufficient to cause profound changes. Figure 11 shows the almost complete restoration to normal conditions after withdrawing 100 c.c. of air from the left pleural cavity. The child made an uneventful recovery.

Because of such evidence as this it seems to me that certainly one of the most important considerations of the vital capacity as related to thoracic surgery concerns the question of pressure effects. That is the chief point that I wish to make. There is really no lack of harmony between such a point of view and the conception of Yates. It is quite obvious in the case of this child that if she had happened to have a low vital capacity the amount of disturbance which she experienced from the alteration of intrapleural pressure would probably have been enough to cause death.

DR. HOWARD LILIENTHAL: I notice that we are getting accustomed to using the term "atelectasis." That is only lung tissue with no air. I should say a potential atelectasis existed with the closed chest. Perhaps there are some cases in which the term may be used, but it should be qualified.

DR. J. L. YATES, Milwaukee: Members of this association are indebted to Drs. Peaboby, Graham and Churchill for their illuminating contributions to a discussion of cardiorespiratory diseases, which are provoking ever greater losses from death and disability. They have illustrated again the need as well as the efficacy of coordinated laboratory and clinical studies for the advance of therapy, which can be neither purely medical nor purely surgical.

Dr. Peabody, in discussing the values of vital capacity in the treatment of cardiac lesions, like Dr. Miller in his consideration of pulmonary lesions, laid greater stress on prognostic significance. He stated that vital capacity was said to measure only one phase of respiration, i. e., ventilation, and was accused of being nonspecific in failing to indicate given lesions.

Vital capacity measures the efficacy of the most important function of the living, external respiration, which depends on coordination of breathing and circulation. Reduced vital capacity indicates malfunction in both circulatory and respiratory apparatuses and when interpreted with other data locates the initial lesion and indicates the treatment required.

Dr. Peabody, as usual, went directly to the sources of error, and pointed out the subjective nature of estimations of vital capacity. A proportion of healthy persons cannot use a spirometer well. A larger proportion of patients fail to employ it properly. Spirometers are not available everywhere. Vital capacities registered after periods of rest and of activity and after one deep inspiration or several deep inspirations are dissimilar. A standardization of methods is desirable. A simpler means of estimating external respiration is even more desirable. One method is to determine how long the breath may

be held after one deep inspiration. Here again the personal equation is influential. Apparently, when the breath holding time is materially reduced to twenty seconds or less, external respiration is seriously impaired and myocardial incompetence is virtually proved.

Dr. Graham's criticisms have already been answered in Part II. We are coming to the same conceptions from different starting points. Divergence of opinion has helped both of us to better perceptions without impairing our friendship. Hence there is no hesitation in stating that the data he presented with the pictures of the chest of the child suffering from traumatic pneumothorax substantiate our contention. The limited amount of pneumothorax present, as proved by the slight degree of positive pressure, would have been well tolerated had the patient's circulatory unit been competent. I want to than Dr. Graham for just criticisms and for generous commendation.

Dr. Churchill's work is splendid and in keeping with the high standards of the physiologic laboratories at Harvard. He should continue his investigations and extend them to include observations on animals of thick pleurae and under conditions simulating human ailments, adding roentgenography and roentgenoscopy to his procedures.

We believe our hypotheses to be sound in principle. We do not believe they will be proved to be complete or correct in detail. We hope for an early discovery of the truth in order that better therapeutic measures may be developed promptly.

VITAL CAPACITY FOLLOWING LOBECTOMY

HOWARD LILIENTHAL, M.D.
NEW YORK

Although the number of lobectomized patients under the observation of any one surgeon must necessarily be small, yet the report of their condition months or years after operation cannot fail to be of scientific value. As a criterion of normal health the vital capacity should not be neglected and it may finally become of importance in deciding on the comparative value of various operative procedures. It must, however, be considered as a single, though significant, factor in estimating the state of health of a patient after resection of the lung. To the patient himself, provided he is comfortable and able to lead an apparently normal life, the vital capacity will probably be of far less moment than fetor, cough, fever and expectoration. From the surgeon's point of view a reading approaching normal should not be considered as important as the elimination of the signs of disease for which the patient sought aid. The dangers of hemorrhage, cerebral complications and amyloid degeneration, ever present in chronic suppuration of the lungs, are no longer to be feared when the septic parts have been extirpated. They still exist, however, when even a small portion of the disease remains.

The ability to work or to exercise violently may or may not have an important relation to the readings of the spirometer and from my own observation I conclude that this ability depends more on the condition of the heart than on the vital capacity of the individual. As an example of this I may cite Patient 1, a man, who with a subtotal pneumectomy of the right side has remained well with a small thoracic fistula for eight years, has been twice married, and who is able to dance "seventeen consecutive dances" without fatigue. This patient was an adult at the time of his pneumectomy. In this case it is not possible to determine the present vital capacity accurately because of the bronchial fistula. His spirometer readings, however, show less than half of the normal. In three other cases in the accompanying table, violent exercise is taken without distress and in one instance, although I have not been able to secure a reading, the patient is able to enjoy athletics, including horseback riding. I have found that when the lobectomy has been performed during childhood the development of the remaining part of the lung takes on a compensatory character with the establishment of normal or nearly normal vital capacity, although so far as we know, the compensatory aeration is of an emphysematous nature. Thus far, in my list, there have been no deaths following recovery from lobectomy and the opportunity for pathologic examination of the lungs

is therefore lacking. Of course, this type of emphysema does not resemble the disease known by the same name in which, owing to the rigidity of the chest, the vital capacity is of necessity lowered.

A series of readings before operation would be useless because these patients are unable to expel their normal quantity of air even from the unaffected parts of the lung on account of the spasmodic coughing which accompanies the effort. As to the tests after recovery, there appears to be little doubt that the spirometric readings will show an increase of vital capacity as a result of practice and this has been remarked by some of my patients. Also, there are great individual

Summary of Cases

Case	Sex*	Age at Operation	Lobectomy	Time since Operation, Years	Weight, Pounds	Vital Capacity	Percentage of Minimum Normal	Remarks
1	♂	26	Right subtotal.....	8	115 (52.1 kg.)	1.1	30	Bronchial fistula (plug); reading taken by patient himself in distant city; probably inaccurate
2	♀	16	Left lower and part of upper	5	116 (52.6 kg.)	2.5	93	Well and active
3	♀	33	Middle.....	9½	150 (68 kg.)	2.2	68	Leads normal life
4	♂	11	Middle, lower, part of upper	3	79 (35.8 kg.)	1.4	60	Small fistula; athletic
5	♀	18	Left lower.....	3½	120 (54.4 kg.)	2.4	85	Slight cough; otherwise well and active
6	♂	8	Right lower.....	10	144 (65.3 kg.)	3.2	89	Active; perfectly normal
7	♂	16	Middle and parts of adjoining lobes	10	140 (63.5 kg.)	3.1	88	Well and active
8	♂	6	Left lower and part of upper	2	41 (18.6 kg.)	0.6	40	Fistula from bronchial remains of upper lobe; school boy
9	♀	8½	Right upper.....	6	73 (33.1 kg.)	1.6	80	Does fancy dancing
10	♀	14	Right lower.....	5	166 (75.3 kg.)	2.5	71	Plays basket ball
11	♂	3¾	Right lower.....	11	109 (49.4 kg.)	3.2	106	Normal, well developed boy

* In this column, ♂ indicates male; ♀, female.

differences in the ability of persons to get what may be called the "trick" of filling and emptying the lungs to the best advantage. I know that many observers who employ the spirometer in cases of cardiac disease maintain that the readings are constant within negligible limits but I am convinced that intelligence and practice will make differences which ought to be taken into account. The postoperative readings are usually but not invariably lower than those which should be indicated by the capacity of the normal individual. It also seems to me that the frequent use of the instrument tends to produce an actual increase in the vital capacity because of the exercise of the respiratory muscles and the increased mobility of the thoracic framework.

THE MEDICOSURGICAL BORDERLAND IN THORACIC TUBERCULOSIS

DAVID A. STEWART, M.D.
Associate Professor of Medicine, Manitoba University
NINETTE, MANITOBA

A century ago the Oregon controversy began to wax hot. Some on our side thought British territory should extend to the Columbia river; some on the other side raised the cry of "Fifty-four forty or fight." So a boundary commission was appointed, and we have lived happily forever after.

I know of no heartburnings about the boundary line between ordinary nonsurgical, or medical, care of pulmonary tuberculosis, and extraordinary, or surgical, care; yet naturally those who approach from the side of surgery do not see the line exactly where we do who make our approach as physicians. That is one good reason why such cases need, not a sort of combination surgeon-physician or physician-surgeon but two men, a physician and a surgeon, with two kinds of experience and two points of view, discussing every phase with mutual understanding. If we are to sit, then, as a sort of high court or boundary commission, it is not to separate rivals, but rather to mark proper limits to an ever widening area of friendly cooperation and helpful alliance between medical and surgical methods in the treatment of pulmonary tuberculosis. And we may be quite sure that the lines staked today will be changed tomorrow.

From time immemorial the physician has occupied pretty much the whole territory, occupies it still, and indeed should continue to occupy it. One with the temperament and training of a physician is content throughout long, tedious months and years to watch Nature bring about slow, gradual changes by absorption, calcification and fibrosis. It is his office to help in the building up of bodily resistance by meeting complications as they arise, by the ordering of a daily hygienic-dietetic routine, by regulation of rest and activity, and, most of all, by reaching the mind of the patient and giving him faith. In later years there have been added to his armamentarium tuberculin, phototherapy, and, best of all, the bloodless, semisurgical procedure of artificial pneumothorax.

Into this medical domain the surgeon has come, a welcome ally, with his more drastic methods, especially when the cure threatens to fail on account of mechanical difficulties that he can remove. By a thoracoplasty, a phrenicotomy, a pneumolysis or a drainage he may brilliantly turn defeat into victory. But the main strategy of the long drawn out campaign, both before the surgical event and after it, is medical.

If surgery is to begin where medicine fails, naturally the big question is just how far can medicine go, and where does it fail? It may easily be forgotten in a proper enthusiasm over a new surgery that there is also a new medicine.

Statistics of cases completed twenty years ago tell a sorrowful tale, but there is a newer and a better story. In twenty years the sanatorium has evolved from a collection of huts in the wilderness which almost boasted of its primitive appointments to a well equipped hospital. The beds available, and especially the facilities for close bed care, have increased in geometrical progression as the years have passed. The influence of the roentgen ray has been revolutionary, not in diagnosis only, but as a teacher of pathology and as a guide in treatment and prognosis. Heliotherapy has come in, and pneumothorax and a better understanding of intestinal ulceration. Some old things have passed away, and there is much that is new. In the older days of few beds, long waiting lists, minimum terms of treatment, and no roentgen-ray examinations, symptoms were too much considered and the disease too little. A man put to bed for symptoms and focus of disease should not be let up when symptoms only have cleared, but should be kept there until the focus has done its maximum clearing also.

This ultimate in treatment, which may mean many months in bed after cough, expectoration and fever have been forgotten, and the patient's appearance has become a byword among his friends, takes time and beds and therefore money, so cannot be made fully available even yet for all who should have it. But that there is such an ultimate in treatment, even without pneumothorax, should be known and appreciated.

A big element in the new medicine, perhaps the greatest single advance in the treatment of tuberculosis in the last generation, is artificial pneumothorax. Where indicated, it doubles the chances of recovery. It is essentially a surgical procedure, applying pressure by mechanical means to a local area to produce local and general effects. If one application were enough it would likely remain a surgical operation; but as it needs to be repeated frequently at irregular intervals on general indications, in the come and go of symptoms, it must necessarily be applied by whoever is in charge of the patient.

It is, I am convinced, a better measure than any of us, however enthusiastic, have made of it. Its range should extend to earlier cases, and to later ones also. The older teachings, that the good lung must be really good, and that collapse to be of any use had to be complete, have both gone by the board. Pneumothorax has a wonderful elasticity. Even gross bilateral disease that could never be considered for thoracoplasty may be helped by a considerable collapse on one side, or a little on both sides, alternately or even simultaneously. Where adhesions are

not troublesome there may be a selective collapse of the most affected lobe, with the rest of the lung functioning, even selective collapses at both apexes while both bases carry on. And while the collapse of gross lesions should be long continued or even permanent, there are small acute outbursts of disease that may be successfully quieted by a few fills. The collapse of one side as a rule affects disease in the other side, not adversely, but favorably. Pneumothorax is really a bloodless amputation of diseased tissues which can be done sparingly or more radically, temporarily or more permanently.

If in spite of bed rest cavities seem likely to form, the indication for pneumothorax is immediate. When breaking down has occurred, even apical, and with the usual adhesions opposite, pneumothorax may yet obliterate them if used with patience and perseverance.

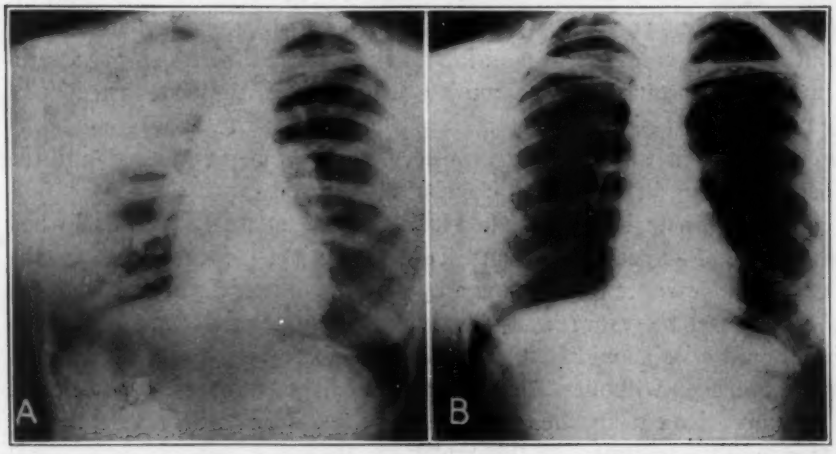

Fig. 1.—*A*, gross extensive disease, especially in right lung; *B*, eighteen months later, both lungs comparatively clear; rest treatment only given.

The arch enemies of pneumothorax, as is well known, are adhesions and fluid. But it is remarkable what may be done with these, as with other enemies, by practice of patience and perseverance. Even adhesions beyond the boldness of Jacobæus will gradually attenuate and allow of satisfactory collapse. This may be done at low intrathoracic pressure, indeed at negative pressure. The essentials are time and patience, not force; tact and diplomacy, not bluster and abuse. The Jacobæus method of breaking into the chest, poking about, cutting and burning, with 6 per cent. casualties, seems an excellent example of what not to do, of doing elaborately and dangerously what can be done in most cases simply and without danger, though slowly, it is true. Except in unusual cases much the same might be said of the open operation for the cutting of adhesions.

To what percentage of cases is pneumothorax applicable? Singer's 5 per cent., suggested last year, Parfitt's 10, Blanchet's 10, Webb's from 5 to 10, are, I think, low. Saugman's 32 per cent. must have been in a group of cases specially selected for treatment of this type. I am applying it in 15 per cent. of patients admitted, and in 25 per cent. of the patients in residence. I recall few regrets for having tried it, but many for not having used it. Its maximum usefulness can be reached, perhaps, only under hospital conditions of close observation, ever ready roentgenographic and fluoroscopic checking before, after and between fills. But in or out of hospitals it is a method by no means used to the limit.

PHRENICOTOMY

So far the measures discussed have been medical. When a physician turns to consider surgical measures, the most attractive operation of all, perhaps because the least bloody, is phrenicotomy, done as early as 1884, and practiced on the continent since 1911, yet comparatively new and

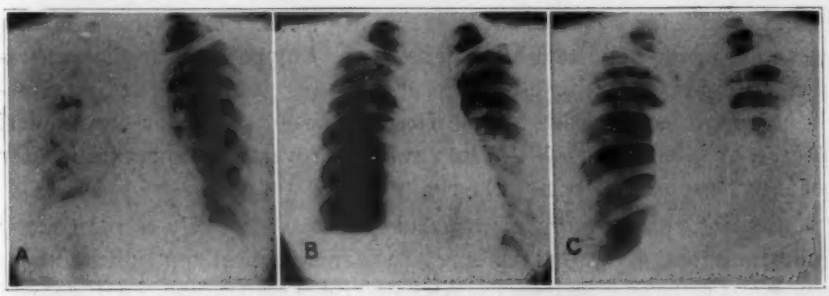

Fig. 2.—*A*, gross acute disease of right side, with cavity at apex; *B*, after pneumothorax, right lung well collapsed in spite of adhesions, cavity partly collapsed, showing plainly; *C*, lung still further collapsed (pneumothorax), cavity has disappeared, adhesion attenuated.

untried on this continent. Its literature bubbles with the optimism of a flower seed catalogue or the prospectus of an oil company. Moreover, we are even offered this operation on trial; paralysis of the nerve can be temporary.

It would seem that this therapeutic paralysis of the half diaphragm by section of the phrenic nerve has been in fairly general use for only four or five years; that in one series of 240 sections of the nerve there was not a single serious accident; that the diaphragm rises on the paralyzed side from 3 to 7 cm., occasionally 11, that is, from 1¼ to 2¾ inches, in at least one case, 4; that thoracic capacity on the affected side is reduced from one sixth to one third; that section of the nerve brings such results in 80 per cent. of cases. It has the further advantage that, like pneumothorax and unlike thoracoplasty, it can be made a temporary

measure. Adhesions do not form to prevent subsequent pneumothorax; expectoration is not hampered, but rather helped by paralysis of the hemidiaphragm.

If phrenicotomy should fulfil even a fair proportion of these promises, what uses can be made of it? It might occasionally be substituted for a pneumothorax in an early lesion or small basal lesion, or in gross bilateral disease when more thoroughgoing measures cannot be applied. Its best use would seem likely to be as an adjuvant to pneumothorax. As Sauerbruch has suggested, it could test out the advisability of pneumothorax or thoracoplasty by throwing temporarily increased work on diseased lungs. In bilateral cases it might give a smaller measure of stasis on one side to help out more complete collapse by pneumothorax on the other. An incomplete pneumothorax above and a raised diaphragm below should be a sort of upper and nether millstone between which an obstinate lower lobe could be dealt with. Perhaps the most attractive possibility of all is that it might reduce the residual pleural cavity in a successful pneumothorax and so lengthen the intervals between fills—a practical gain for a patient able to return to work. It may have further uses in stopping persistent hemorrhage; relieving pain due to diaphragmatic adhesions; lessening effusions; substituting for abandoned pneumothoraces; protecting a lower lobe from aspirated secretions from apical disease, or in effecting a little temporary improvement in preparation for some more thoroughgiving collapse.

In short, this new procedure would seem not unlikely to meet many indications, and give worthwhile returns for a surgical expenditure negligible in risk and discomfort. Alexander believes "that the time will come when almost every artificial pneumothorax undertaken in the best clinics will be preceded or followed by a radical phrenicotomy." My idea is that it should follow, not precede, pneumothorax.

PNEUMOLYSIS, OR APICOLYSIS

If surgeons were willing, another of the less drastic or compromise measures that physicians would like to ask for is pneumolysis, or apicolysis. We know very well what we would like to do, but the general opinion seems to be that this cannot be done satisfactorily. In not a few cases disease clears up satisfactorily in the lower two thirds of the lung, but becomes residual in the apex. Fibrosis has done what it can. The upper lobe has been pulled up, the surrounding tissues pulled over until they will pull no farther. Progress is at an end. There usually is a considerable cavity keeping up cough and expectoration, and some toxemia. The patient has become a chronic patient, too well for bed, yet not well enough for ordinary living; tired of restrictions, yet not fit to neglect them; on the verge of being well, but still sick. So he

faces, at the best, chronic semiinvalidism; at the worst, extension, sepsis or degenerative changes. General treatment can do little more than help him to hold what he has. His difficulty is mechanical. Pneumothorax will do the unexpected sometimes, but seldom in this situation. What else can be done?

"Complete thoracoplasty," the surgeon says, and he may be right. But the punishment seems scarcely to fit the crime. At most the upper third is guilty, and the innocent two thirds must also suffer. Can a new apicolysis be devised? Would it help after cutting a few ribs, instead of filling, to apply pressure, as was suggested last year by Dr. Leonard Freeman of Denver? Mechanical compression, by posture, shotbags, binders, jackets, plaster casts and even by springs and thumbscrews has come to have a fairly wide applicability to the various phases of pulmonary tuberculosis. Could external pressure take some part in helping a residual apex? At any rate this condition needs surgical help.

Fig. 3.—Right apex showing residual lesion with cavity; such lesion would seem to call not for thoracoplasty but some form of apicolysis.

There is room also for compromise between nonsurgical and surgical measures, or at least between less and more drastic in the treatment of tuberculous collections of pus in the pleural cavity. With a considerable allowance of patience most such collections will clear up without any interference whatever, others with the help of a few aspirations. Even empyemas of long standing, with thick pus and an underlying lung collapsed for many months, not infrequently can be cleared up and the collapsed lung coaxed out by the aspiration, under close roentgen-ray control, of moderate amounts, frequently enough to keep up a fairly constant vacuum. Plastic surgery should practically never be necessary to clear up such tuberculous collections, unless fistulas are present, and not always then.

THORACOPLASTY

So far I have discussed general treatment and what it can do, pneumothorax, phrenicotomy, pneumolysis, mechanical means of compression, the clearing up of empyemas by patience, or, at worst, by the needle, everything but thoracoplasty. The inference must be that to the physician thoracoplasty appears pretty much a last resort. This does not mean that it is to be applied only in extremis and surgery made a dumping ground for medical failures. The surgeon is right in demanding his cases early, and so is the physician; but neither get them. We are truly grateful for thoracoplasty, and think it should be done earlier and oftener, but chosen only when milder measures will not do the job. This opinion is of course unanimous. I know of no authority who recommends a thoracoplasty when a good pneumothorax can be done.

Fig. 4.—Appliance used at Manitoba Sanatorium; secures partial immobilization and in some cases also a small measure of collapse.

Pneumothorax has many advantages. It can be done with no shock, mental or physical, no laceration, no inlet for infection, and with a danger to life comparable to that of a general anesthetic or persistent thymus. The shifting of viscera can be gradual, under full observation and, usually, control. Collapse in many cases can be partial, complete, temporary or permanent by choice. A full air collapse is at least a third greater than a complete surgical collapse.

Thoracoplasty, on the other hand, is a major operation, with all the mental and physical accompaniments; from it there is no going back. Its costs are higher in shock, risk, pain, and even the time cost is by no means small.

Thoracoplasty pretty much begins where pneumothorax leaves off, but not exactly. As Dr. Archibald has pointed out, tuberculosis bad enough to need thoracoplasty is practically never one-sided, and indeed in all his cases there was involvement of the other side, sometimes active. I believe that the amount of contralateral lung involvement allowable with thoracoplasty will be increased somewhat, as has been the case with pneumothorax. Still there will be gross bilateral disease which may ask for a small air collapse, yet not for a surgical collapse. Pneumothorax can skate on thinner ice.

And I still maintain—though I am surprised at my own temerity—that some may be bad enough for air collapse, and fail to get it, and yet not be quite bad enough for surgical collapse. Between the two, another recourse to more complete rest with, perhaps, a phrenicotomy may be

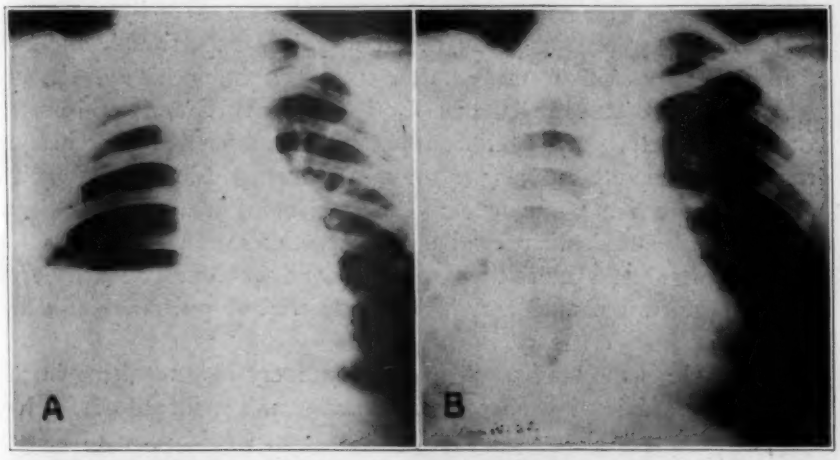

Fig. 5.—*A*, empyema on right side of nearly two years' standing; *B*, right lung almost completely reexpanded by frequent aspirations; full health restored.

tried. Earlier diagnosis and earlier pneumothorax would sometimes allow a breathing space after pneumothorax failure before thoracoplasty.

Dr. Archibald last year described admirably the three more suitable classes as the chronic fibrotic with cavitation and a good deal of shrinkage; the extensive fibrotic with consolidation but little destruction, and the more doubtful, more or less active exudative, usually with cavitation. The greater the tendency to fibrosis, the less the risk, and the better the results. Alexander quotes Sauerbruch as saying that fibrosis is more marked after thoracoplasty than after pneumothorax.

The chief indication for thoracoplasty is advanced or advancing disease, fairly unilateral, and complicated by adhesions. Here is a mechanical difficulty that calls for a mechanical solution. Great displacement

of viscera, or hemorrhage when lung collapse is not possible may indicate thoracoplasty. An acute rapid type of disease is usually a contraindication as well as bilateral disease, or severe complications in other organs, or such conditions as would rule out any other major operation.

The plea is made that the more radical procedure should sometimes be used to save time. Does thoracoplasty save much time? Dr. Carl A. Hedblom said last year that if a choice had to be made between three months and three ribs he would choose the three months. But what if the choice were nine months or three ribs, or twelve months or eleven ribs? Sometimes the patient gets both the fine and the imprisonment, loses the eleven ribs and the twelve months, or more, as well. If surgery must be done, it is best that it should be done quickly. But the cure must go on after operation, almost as before. When thoracoplasty is indicated it does not save so much time but life.

A weariness with long continued pneumothorax refills is scarcely an indication for the plastic operation. It would take the trouble and cost of a great many refills to make up the total of a thoracoplasty. In any case the intervals steadily lengthen through gradual changes, and phrenicotomy may help. The likelihood of empyema sooner or later in long drawn out pneumothorax argues for a permanent closing of the cavity, but on the other hand, a pyopneumothorax without fistula usually clears up readily without plastic operation, and sometimes even with fistula.

Adhesions should be dealt with patiently and should not be considered to indicate operation until a full, deliberate trial of pneumothorax has been made.

How wide is the borderland in which surgery aids medicine in the treatment of pulmonary tuberculosis? Saugman's estimate of from 4 to 8 per cent. is high. Alexander's 2 per cent. would seem to be not far from right at present; but may be found after further developments in thoracic surgery to be low.

CONCLUSIONS

The most possible in medical care, with all new facilities and methods, is much beyond the utmost of a few years ago or the present average.

Pneumothorax is elastic, and applicable to a fairly wide range of cases, perhaps to 15 per cent. or more, of pulmonary tuberculosis.

Though as yet scarcely tried, phrenicotomy seems to promise a fairly wide usefulness, especially as adjuvant to pneumothorax and thoracoplasty.

Residual chronic disease walled up in the apex needs help from surgery in which there is less danger and destruction of tissue than in a full thoracoplasty. Old methods of pneumolysis may be unsatisfactory, but the need exists.

Tuberculous empyemas are often cleared up, indeed usually, without need of drastic treatment.

Thoracoplasty has saved life and is indicated in perhaps from 1 to 2 per cent. of cases of pulmonary tuberculosis, yet should be applied only when the ordinary hygienic-dietetic routine, pneumothorax, perhaps phrenicotomy, or a combination of these, cannot give an equal chance of saving or prolonging life.

Earlier opportunity to do thoracoplasty, which is desirable, could best be found by earlier initial diagnosis, earlier medical treatment, and especially by earlier pneumothorax. The patient should be tried out in these easier stages before thoracoplasty, but earlier than is now done.

THE MEDICAL CARE OF TUBERCULOUS THORACOPLASTIC CASES

S. ADOLPHUS KNOPF, M.D.
NEW YORK

For a mere physician to be invited to talk before an assembly of eminent surgeons is always an honor and I wish to express my grateful appreciation of this distinction. To be privileged to talk on the care of the patient who is about to submit or has just submitted to a serious operation for a disease that for centuries belonged entirely to the domain of internal medicine is the best demonstration that there is but one healing art. Thanks to the advances of surgery and medicine, the surgeons and physicians are now joining hands in a successful combat against a disease which was once considered the most deadly and hopeless affliction mankind has fallen heir to and which has justly been called the great white plague.

When studying the medical and surgical aspects of pulmonary tuberculosis today, we may well replace the old pessimism about the incurability of the advanced cases by a more hopeful attitude because surgeons have united with physicians in their treatment. Though fearful that I might fall short of your expectations, I was glad to accept your invitation to give you my ideas on the care that should be given, both immediately before and later on, to the tuberculous patient operated on by thoracoplasty.

I may presume that the most careful attention has been given to the patient prior to his thoracoplastic operation and that his resistance has been increased as much as possible, so that both physically and mentally he is prepared for the surgical shock. This shock is, of course, greatly minimized by the use of local instead of general anesthesia, and by the graded operation.

There is nearly always the danger of a patient vomiting during the anesthesia and that the aspiration of food particles may result in an aspiration pneumonia. As a preoperative precaution therefore, the surgeon as well as the anesthetist should make sure that the patient's stomach is virtually empty, and in doubtful cases it may even be advisable to resort to lavage of the stomach prior to the beginning of anesthesia. The anesthetist should see that the foot end of the operating table can easily be elevated so that when he notices any diaphragmatic contraction during anesthesia indicating the possibility of the patient vomiting, he should immediately raise the lower portion of the body and thus facilitate the expulsion of the stomachic contents.

I myself am opposed to ether anesthesia for all kinds of tuberculous patients, but particularly in operations involving the abdominal or

thoracic cavities or the upper respiratory or digestive tract. All operations in these regions should be preceded by a thorough cleansing of the nasal and buccal cavities. One can never be sure of the type of pneumococci the patient may be harboring in his mouth, nose or throat. During the recent war it was my privilege to publish, by authority of the Surgeon General, an article entitled "Pneumonia Among Soldiers in Camps, Cantonments and at the Front." As a means of disinfecting the upper respiratory and digestive tracts and perhaps killing the virulent types of pneumococci, I suggested the following solution which had been recommended by Kolmer and Steinfield:[1]

	Gm. or C.c.
℞ Ethylhydrocuprein hydrochlorid or quinin bisulphate.....	0.005
Liquor thymolis	5.0
Distilled water, sufficient to make.....	50.0

Before the final cleansing of these regions with the solution indicated, an important measure against the aspiration of infected material from bronchial secretions or cavities consists in urging the patient to repeat his usual morning pulmonary toilet once more an hour before the operation. Nearly all tuberculous patients cough more freely in the morning and expel profusely the secretions accumulated over night.

Let us for a moment consider the symptoms which may arise after the operation and which should be treated or rather anticipated by the surgeon in attendance, if this has not already been done by the medical attendant prior to the patient's transference to the surgical service. I question the wisdom of telling the patient that because he will be given local anesthesia he will feel no pain at all during the operation. I should rather tell him that it may hurt some, but assure him that with a little courage he will be able to stand the pain. It is always surprising to see how much a soothing word from a gentle voiced physician or nurse helps the patient to bear the pain that often is inevitable with local anesthesia.

The patient's condition should be an index to the number of ribs to be dissected at one séance. Although the patient may be asked how he feels and whether he could stand the removal of another rib, his own feeling, influenced by the administration of the opiate preceding the operation and the local anesthesia, may lead him to think that he can well stand the prolongation. However, his pulse, the character of his respiration, and the general aspect alone should be the decisive factors. I believe no harm has ever been done by making the graded operation even more graded than originally intended.

The most distressing symptom from which the majority of tuberculous patients suffer is cough, and it becomes especially troublesome and painful when the secretions are tenacious. I know of no better

1. Kolmer, J. A., and Steinfield, E.: Disinfection of Pneumococcus Carriers, J. A. M. A. **70**:14 (Jan. 5) 1918.

way to overcome this than to administer as large a quantity of chlorid of sodium as the patient can take with his food, and begin with this several days before the operation. The desire to drink water is naturally increased and, unless the patient has diarrhea, only good can come from this. While I do not pretend to be able to explain exactly why this increased amount of salt should help so materially in lessening the tenacious quality of the sputum, we may perhaps presume that it is effected by the process of osmosis. Be this as it may, I know from experience that it is as good a dietetic remedy as we have to ease the cough and to facilitate the ejection of the sputum.

Very varied indeed is the experience with cough after the completion of thoracoplastic operations. I have asked quite a number of surgeons to be good enough to answer the following question: "Does the average tuberculous patient after having been submitted to a graded thoracoplastic operation cough more or does he cough less, and is the quantity of sputum increased or diminished?"

In the experience of Archibald, Graham, Green, Keller, Lambert, Lilienthal and Whittemore there is a diminution of cough and sputum immediately after the thoracoplastic operation. On the other hand, Meyer, Ramsdell, Torek and Wells have found that cough and sputum are increased in the first few days or a week after the operation and later gradually diminished.

After an operation on the chest, cough is just as painful and distressing as it is after an abdominal or pelvic operation, perhaps even more so, and whatever can be done to diminish its frequency without suppressing the secretion will be of advantage and hasten the patient's recovery. However, it must be borne in mind that for several days immediately following the operation it is of greatest importance in the prevention of aspiration pneumonia or stasis pneumonia, to urge the patient not to suppress the cough with expectoration, in fact to let him do this as often as he can, to get rid of infectious secretions. If the patient will support the operated side with his hand when he expects to cough, or have the nurse do this, the pain and effort will be materially lessened. It is of course presumed that most patients coming to thoracoplasty have learned to discipline their cough and to cough only if they feel they must expectorate. Nevertheless, it may be well to impress on the patient again that the useless cough, that is, cough without expectoration, can be avoided by will power. This will power, however, may not be as strong as it was before the operation and it sometimes becomes necessary, for a short period of time, to administer some cough remedy. I know of no better medicinal agent than small doses of heroin. I am in the habit of giving one-twelfth grain (0.005 gm.) of heroin every four or six hours and decreasing the frequency as the cough

subsides. I have found the following a pleasant mixture to administer this narcotic:

	Gm. or C.c.	
℞ Heroin hydrochlorid	130	gr. ij
Diluted sulphuric acid	3	♏ xlv
Glycerin	32	ʒ j
Cherry laurel water	16	ʒ iv
Syrup of wild cherry	16	ʒ iv
Distilled water sufficient to make	90	ʒ iij

M. Sig.: One teaspoonful from every four to six hours; less should be taken as cough subsides.

To avoid any possible addiction to the use of heroin, as soon as the cough begins to lessen I alternate the heroin mixture with one in which the active principle is codein in a dose of one-eighth grain (0.008 gm.). For great mental distress or apprehension and for physical pain likely to follow the operation, I believe it is customary for surgeons to administer a fairly good sized dose of morphin hypodermically. It may be necessary to repeat this a few times after the operation.

The complication most feared after a thoracoplastic operation is, of course, the aspiration pneumonia in the healthy or relatively little invaded apex. We have already indicated the measures to be taken to avoid aspiration of food particles during anesthesia. To avoid the aspiration of infectious material coming from diseased bronchi or pulmonary cavities I know of no better means than to restrict the respiratory movements in that region. This may be done by strong adhesive straps, after the method devised by Edison (Fig. 1), or by a plaster-of-Paris short jacket, as devised by Forster of Colorado Springs (Fig. 2). The latter permits the compression of the apex or the upper lobe in part or entirely with the aid of inflatable rubber bulbs; Sewall's belt (Fig. 3) also may serve, or my own saddle bag (Fig. 4), which can be made in any size. It consists of a weighted band placed across the opposite side of the chest when the patient is in the recumbent position. By putting sand or shot in the container, the weight of the bag can be regulated and it should be placed to straddle the nonoperated side and thus inhibit respiration. To retain it in place bands can be attached and tied. The patient should also, of course, be cautioned to avoid deep respiration as far as possible. In the prevention of aspiration pneumonia it is of great advantage if for some time before the operation the patient has been taught to use only diaphragmatic respiration, which will be commented on later.

On rare occasions there may be a postoperative rise of temperature, a condition that should not be treated by heart depressing remedies, but by aerotherapy and hydrotherapy. It may not be possible to carry out the former as thoroughly with a patient in a general hospital ward as in a private room or sanatorium, but it is presumed that our modern surgical wards are well ventilated and if the patient's bed is surrounded by a cubicle or screen, the window in his cubicle may be opened wider

to supply his need for air. I do not believe, however, that the operated patient should be made uncomfortable in midwinter when the outside temperature is low; extremes should be avoided. The operated patient should never be exposed to the danger of being chilled. His body should be kept warm while he breathes fresh air.

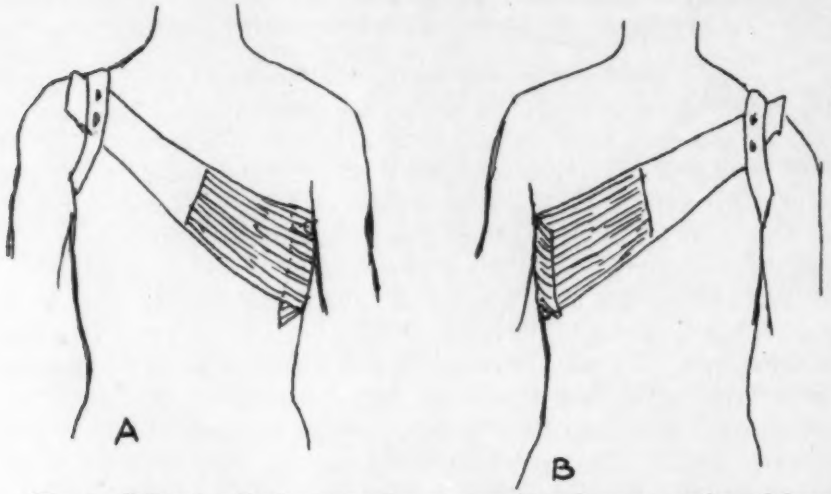

Fig. 1.—Edison's adhesive strap for compression of upper portion of lung: *A*, front; *B*, back.

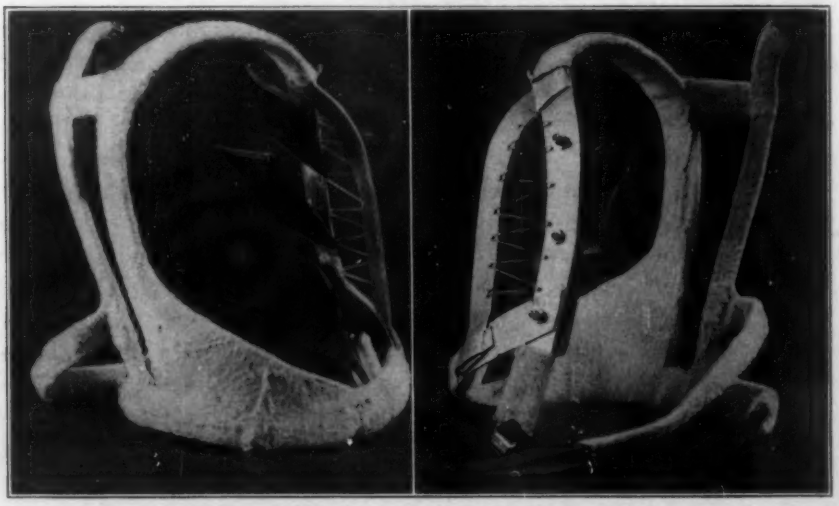

Fig. 2.—Forster's plaster-of-Paris jacket for restricting respiratory movements.

If there is an appreciable rise of temperature, it may be well to resort to hydrotherapy by sponging the arms and legs with water at a temperature of from 85 to 90 F., or lower if the patient does not object, from every two to four hours. The upper and lower extremi-

ties and perhaps also the abdomen should be wrapped in a Turkish towel and the water should be allowed to absorb. The thorax should not be disturbed. In this way aerotherapy and hydrotherapy may be judiciously administered while the patient is still in the surgical division of the hospital.

We next come to the period when the patient is discharged as surgically healed, his right or left lung completely collapsed. Thanks to the compression of the diseased lung tissue, he has become virtually afebrile, with his cough and secretions considerably diminished. However, the fact remains that probably no patient has ever come to thoracoplasty who has had an absolutely unilateral lesion, for the patients ready to have their lungs compressed are as a rule in the third stage of the disease, that is to say, there is extensive localized infiltration or consolidation in one or more lobes or disseminated areas of cavity formation, and when a case has advanced to this stage, there is usually a partial invasion of the other less affected side. In the many years of my service at the New York health department's Riverside Hospital for the consumptive poor, where we take only the advanced cases, I do not remember a single absolutely unilateral case. One side may be little involved, but I repeat that when the patient has reached the stage just described, we cannot hope to find an absolutely unilateral condition. To protect the patient who has one side totally collapsed but has a beginning invasion of the opposite side is the most important thing after thoracoplasty. All our armamentariums—aerotherapy, climatotherapy, mechanotherapy, respirotherapy, massotherapy, hydrotherapy, heliotherapy and even psychotherapy—must be utilized to prevent the still existing tuberculous lesion from advancing further, and if at all possible to bring about a complete arrest. To this end the patient should live twenty-four hours out of every twenty-four in as fresh and pure air as is obtainable. The ways in which this can be accomplished will vary with the circumstances and the climatic conditions, for no one ideal climate exists; some patients will feel best in cool, some in warmer climates. Those inclined to dry catarrhal conditions will do well in moderately moist climates; those with moist catarrhs in hot dry climates. Where the individual patient can live outdoors the greatest number of hours of the day and the greatest number of days of the year in fresh, pure air with the greatest comfort is the ideal climate. Patients in poorer circumstances, as a rule, cannot obtain those ideal conditions and they must be content with their home climate. They may, however, seek environments where the air is relatively free from dust and other impurities and obtain as much sunlight as possible.

Of the value of mechanotherapy we have already spoken, and I may say here that even after the patient's recovery from the effect of

the operation and aspiration pneumonia is no longer feared, the various appliances described in the foregoing as useful for the prevention of aspiration pneumonia may be employed continuedly to restrict as far as possible the respiratory movements in the portions of the lungs invaded by the tubercle bacilli. I often recommend and use these appliances for the restriction of respiratory movements in pulmonary tuberculosis when neither artificial pneumothorax, section of the phrenic nerve, nor thoracoplasty are indicated or possible.

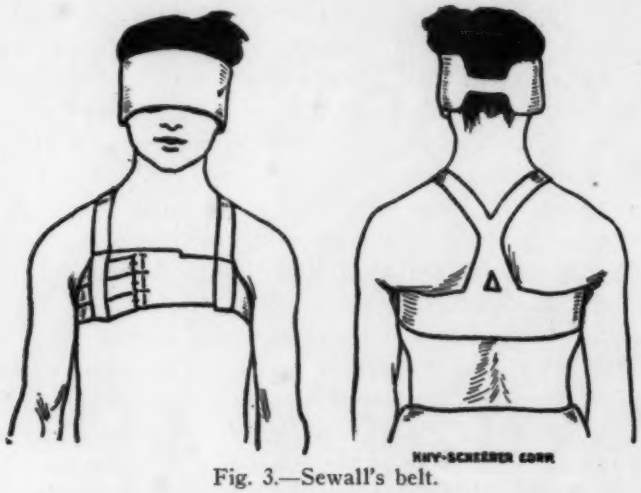

Fig. 3.—Sewall's belt.

Fig. 4.—Knopf's saddle-bag.

It may seem surprising when I state that in addition to thoracoplasty on one side the respiratory movements of the remaining portion of the lung can be restricted to the diaphragm and reduced in number. The modus operandi for this is the same as that which I devised for controlled diaphragmatic respiration when only the apexes or upper portions of the lungs, on one or on both sides, are involved.

I will give a short description of this method as follows: When being taught the practice of controlled diaphragmatic breathing, it is best for the patient to lie in or on the bed or on a reclining chair, in a semireclining position, with feet extended and slightly separated; this position demands the least cardiac effort against gravity. This position can be obtained in bed by the use of three or four pillows, and on the typical sanatorium reclining chair by regulating the back so that it will be at an angle of 30 degrees. In this position relaxation is most easily obtained. If the patient is dressed, there must not be any garments that would restrict the free exercises of the diaphragm and abdominal muscles. The patient must strive to relax in mind and body and is told to imagine that the respiratory movement begins in the toes of his right foot, the inhalation gradually traveling upward as far as the diaphragm on the right side, then crossing over to the left and gradually descending during exhalation toward the left foot. While, of course, this breathing upward from the toes to the abdomen is merely imaginary, it results in a diaphragmatic breathing, and whatever quantity of air is inhaled passes mainly through the lower portions of the lungs while the upper portions where tuberculous lesions usually are located, are put, if not at complete, at least at comparative rest.

The patient must concentrate his mind on this procedure. He cannot and should not be thinking of anything else during this rest breathing period. The surest way to teach the procedure correctly is to ask him, during inhalation and during exhalation as well, to follow in his mind the physician's hand with index finger pointing as it moves in the upward direction from the right toe and over to the left side of the diaphragm, then downward to the left foot. When the physician's finger has arrived at the left side of the diaphragm, it will pause while the patient may hold his breath a second or two, or longer if he can, and then exhale during the downward movement of the finger. The relation of the duration of the two acts should be five for inhalation and four for exhalation. With some patients ten seconds may be spent for the cycle, five for inhalation, four for exhalation, and one for stopping between inhalation and exhalation. With other patients, particularly in the more advanced cases, it may be necessary to count rapidly and shorten the cycle. Nearly all patients are able to lessen the number of respirations per minute with absolute comfort by stopping after the exhalation two, three or more seconds before inhaling again. In fact, one may leave the duration of the interval between each cycle of the respiratory movements to the ability of the patient to remain quiet before inhaling again. If he is able to hold the air after inhalation several seconds longer, he may also do so.

It will often be necessary to repeat this rest breathing procedure several times before the patient has fully grasped the modus operandi

and does it correctly. A good way for the physician to assure himself that his patient has fully mastered and understood the rest breathing is, while indicating the direction and duration of the inhalation with one hand, to place the other over the upper portions of the lungs, and thus observe whether they are at complete or at almost complete rest, and with his eyes fixed on the abdominal region see that the diaphragm does its work properly. Later on, by placing his own hands one on the chest and the other on the abdomen, the patient may learn to know whether or not he is doing the diaphragmatic breathing correctly and giving the upper portion of the chest the desired repose.

One thing essential is to interest the patient in this rest breathing by explaining to him why this type of breathing is resorted to and the object to be attained. The quieter an organ of the body is kept the less likely it is to become tuberculous and the more easily it is cured. A tuberculous gland heals more rapidly than any other invaded organ in the body. Skin tuberculosis or a tuberculous bone or joint will heal more quickly when put at rest or subjected to as little movement as possible, and so does a lung completely collapsed by artificial pneumothorax or thoracoplasty. Animals which breathe slowly contract pulmonary tuberculosis less readily than those which breathe fast. We have an example in our domestic animals; the cow, which breathes from sixteen to eighteen times per minute, is far more susceptible to tuberculosis than the horse, which breathes only eight times. Rest of the invaded lung is the great object we physicians try to obtain by all possible means that will not harm the patient.

It will be surprising if I state how easy it is to train a patient to breathe only with the diaphragm and to reduce his respirations in numbers. If a patient is in a habit of breathing twenty times a minute and is able to reduce his respiration to only ten, and to do this rest breathing for ten or fifteen minutes several times during the day, so that the accumulated time he had devoted to it amounts to two and a half hours, he has saved his lungs 1,500 respirations, or 3,000 excursions, or in five hours 3,000 respirations, or 6,000 excursions.

The psychologic effect of this method is likewise of distinct advantage. When the tuberculous patient, during the active stage of his disease, is condemned to absolute inactivity in bed or on the reclining chair, he will often become despondent because he has nothing whatsoever with which to occupy his mind. By resorting to this method of respiration he has something to do which will divert his attention, and the more often he does it the more will he improve his condition.

In this short paper I cannot reproduce the many comments on the method which have been made by eminent physiologists and phthisiotherapeutists, but one of the members of this association, Prof.

Edward Archibald, on learning of my method, stated that it was "a most valuable contribution to the therapy of tuberculosis." One of the greatest European authorities on artificial pneumothorax and thoracoplasty, my late friend, Prof. Christian Saugman of Denmark, wrote:

> I have studied your method with great interest and tried it on myself and was able to reduce my respirations to 3½ per minute without any difficulty. . . . I will employ your method in the treatment of my patients at the sanatorium.

From the reports that have come to me of the results obtained from an extensive trial of this method, of conscious bradypnea, I will mention only the one from Prof. George Dock, formerly of Washington University of St. Louis, now of the Barlow Sanatorium, Los Angeles. Dr. Dock says:

> I am especially interested in this method because I think you have shown a definite way of lessening movement in the part of the lung most affected as a rule. I look on the improvement of the abdominal circulation as of great importance and believe the psychological element introduced is of no little value.
>
> This method is a useful addition to the class treatment of tuberculous patients. The demonstrations and questions raised give many opportunities for learning the many problems and inhibitions of the "lunger." Like all methods that lead to closer cooperation between patient and therapeutist, the work has had a distinctly good psychological effect. In various reports I have had the patients give me I find such statements as the following: helps to relax, quiets the heart, lessens fatigue, increases endurance. I have a very strong impression that the more intelligent the patient the more benefit he is likely to receive from carrying out your adjuvant along with the other necessary measures.

I am not prepared to say that this rest breathing, limited to the diaphragm, may not also help in preventing the greatly feared aspiration pneumonia in the better lung, and perhaps also help to bring about a more rapid formation of fibrous tissue; at any rate, I believe it is reasonable to suppose that such beneficent influence may be obtained thereby. To this end I think it will be good practice to teach the patient the method of controlled diaphragmatic respiration a few days before the operation, and if it is feasible to apply mechanotherapy at the same time by limiting the respiratory movements of the slightly involved apex, it will not be difficult for him to learn to restrict the respiration to the lower portion of the comparatively well lung.

When the patient has learned how to use his respiratory function before the operation as a likely safeguard against aspiration pneumonia, he will be glad to use it as a therapeutic agent to safeguard further his predisposed apex from invasion afterward. Before allowing our patient to resume walking exercises we must see to the strengthening of the muscles of his extremities, which may have become more or less atrophied from disuse. There is no better means to accom-

plish this than simple massage, consisting in friction, kneeding, tapping and stroking in the direction of the venous circulation, which any nurse or relative of the patient could easily attend to. Massage rouses dormant capillaries, increases the area and speed of the circulation, furthers absorption, and stimulates the vasomotor nerves, all of which are aides and not hindrances to the heart action and to nutrition in general. Of course, massage cannot manufacture blood cells or coloring matter, but it can put in circulation those which are dormant in the system. Unless this is done, the result is the condition picturesquely described by the poet-physician, the late S. Weir Mitchell, as "like the want of circulating money during times of panic, when gold is hoarded and not made use of, and interference with commerce and manufacturing results."

By this therapeutic means we not only improve the flabby, disused muscles, but at the same time help to overcome the anemic condition characteristic of almost all tuberculous sufferers. Before leaving the subject of massage I should like to give the opinions of a few eminent tuberculosis specialists on its value. Drs. Edward R. Baldwin and Lawrason Brown, at the head of the Trudeau School at Saranac Lake, are emphatic about massage being an important adjuvant in modern phthisiotherapy, and one almost neglected in this country. Dr. Edward O. Otis of Boston, an equally well known expert in tuberculosis, said: "Massage, I believe, is a valuable means in the postsanatorium rehabilitation of the arrested tuberculous patient and, indeed, before that period in certain cases."

I have already referred to the value of careful sponging with tepid water at any time the patient has an appreciable rise of temperature, but after he is up and about, like all tuberculous patients, he will be quite susceptible to changes of temperature. Aside from the tonic value to the cutaneous, nervous and muscular system of judicious hydrotherapy, I do not know of anything that so lessens the susceptibility to colds as the application of cold water. Of course, with one recovering from a surgical operation or one who has never been accustomed to the use of cold water, it is important that precautions should be taken to avoid the possibility of chilling the patient. At the beginning the cold water application should be made in the form of an ablution, either in the morning when the patient arises from his bed, or in the evening after he has been in bed for about ten minutes and has become thoroughly warm. If necessary the bed can be warmed with the aid of a hot water bag, which may remain at the feet of the patient. It is also well to have the hydrotherapeutic arrangement as near the bed as possible. If the bathroom is not situated close to the bedroom, it is best to use a circular English bathtub, about 3 feet (91.4 cm.) in diameter and 10 inches (25.4 cm.) high, half full of water at a temperature of about 105 F. This should be placed near the bed. The

second part of this simple hydrotherapeutic arrangement consists of a wash basin full of cold water with a large sponge, placed near the tub on a table of ordinary height. The temperature of the cold water can vary from 40 to 90 F. From 40 to 45 is usually the temperature of the water coming out of the faucet. It is best to begin with the cold water at a temperature of 85 and then to go down gradually 5 degrees every four or five days until a temperature of 40 is reached and borne comfortably. It is always well to have the windows closed and the room warm while the patient is taking his cold water application. If in spite of all precautions the patient should fail to react, the cold baths must be discontinued.

The ablution is applied in the following way: The patient stands in the tub with 5 inches (12.7 cm.) deep of water at 105 F.; at the beginning the nurse in attendance, and later on the person himself, takes a sponge soaked in the cold water and squeezes it out first over the back of the neck, then in front over the thyroid, then over the left shoulder, and then over the right, letting the water run down so that the entire body is bathed with cold water. The patient then dries himself quickly, not necessarily very thoroughly, with the aid of a large, rough towel, and returns immediately to the bed. Under the warm cover he will feel warm and the little moisture left on his body will soon dry. Through this procedure reaction is assured, and the patient rarely fails to feel comfortable and to enjoy the cold water application. If the head should get wet accidentally, he should dry it thoroughly. This is a precaution the patient should always take whenever he has washed his head. When the system has become accustomed to the cold water used in this way, the patient can safely resort to the application of a needle bath, a shower bath or plunge.

In regard to heliotherapy, I must confess that in general we have not yet been very successful with the treatment in pulmonary tuberculosis, and in fact a good deal of harm has been done by the injudicious exposure of consumptives to the rays of the sun. The reason of this is obvious when we consider the constant movement of the lung as compared with the glands, the skin, a fixed joint, or the peritoneum and the intestines; all these organs are benefited by heliotherapy because they are at rest, or at least at comparative rest. The failures of heliotherapy in pulmonary tuberculosis are to my mind also to be ascribed to the exposure not having been gradual enough. From my own experience, I have reason to believe that should we follow Rollier's method and begin by the exposure of a few inches of the cutaneous system from below upward at graded intervals and for graded periods, and limit the application of the rays to such portions of the lung as are greatly limited in their movements by an external restriction, collapsed by artificial pneumothorax, by the section of the phrenic nerve or

thoracoplasty, and only at such times when the patient is doing his rest breathing, heliotherapy or even artificial sunlight may be of great value.

Of psychotherapy in thoracoplasty before and during operation we have already spoken. It is of equal value during convalescence and afterward. When the patient is convalescent he must be warned against overexertion on account of his diminished breathing space. He should never walk or work when tired nor to the extent of getting tired, nor when a feeling of dyspnea comes over him. My young colleague, Dr. J. Burns Amberson of the Loomis Sanatorium, has well said:

> Like pneumothorax, thoracoplasty in itself does not remove the tuberculosis. The surgeon sets the stage for better healing, and then, under the supervision of the physician, the patient continues hygienic rest treatment until such healing is attained. To neglect this is to thwart the possible good effects of surgery.

In conclusion let me say, thoracoplasty, if successful, will give the patient a new lease of life and a comparative feeling of well-being which he probably has not experienced for many months or years. Well may we physicians be grateful to our colleagues, the surgeons, who are now helping us by their skill to cure many formerly hopeless cases. There is every reason to believe that with the help of thoracic surgery the time may come when we will no longer have to speak of incurable cases of tuberculosis.

PATIENTS WITH PULMONARY TUBERCULOSIS IN GENERAL HOSPITALS

IS IT JUSTIFIABLE TO REFUSE THEM TEMPORARY ADMISSION TO SURGICAL WARDS WHEN IN NEED OF OPERATIVE HELP?

WILLY MEYER, M.D.
NEW YORK

Today it is generally recognized that pulmonary tuberculosis has become a borderline disease, by virtue of the surgeon's ability to improve or cure a certain percentage of such consumptives whose affliction has proved intractable and irresponsive to any medical or hygienic regimen.

Extrapleural thoracoplasty for the purpose of collapsing the lung with the chest wall to which it has become attached and extraction of the phrenic nerve from the anterior mediastinum are the two operations that principally come into consideration. Neither operation is difficult, technically, and they should be done by competent surgeons in well conducted hospitals everywhere. Untrained surgeons should never touch them.

What is not easy is the proper selection of the patients to be subjected to operation, and the question of determining which of the two operations is indicated in the given case. Scientific cooperation, "teamwork" by internist or phthisiotherapist and surgeon, is here the keynote for further rapid progress in this interesting chapter. Without proper selection great harm will be done to the rôle operative surgery has been called on to take in the treatment of pulmonary tuberculosis; great harm will also be done to the patients themselves. Proper selection of the patients for operation and due regard to indication and contraindication are of paramount importance.

An essential prerequisite in all cases of thoracoplasty, as a correlative to correct operating, is careful nursing, at least for the first postoperative days, such as is furnished for the poor in the public wards, and for pay patients by special nurses in the private or semiprivate divisions of our hospitals.

However, this indispensable condition cannot be fulfilled everywhere at the present time for the reason that a ruling exists in several states, including New York, which forbids admission of these patients to the public wards of our general hospitals, even temporarily. These rulings were made years ago at the time of the beginning of the public fight against tuberculosis. Then much seemed possible by prevention, right or wrong, and of course nobody could know that operative surgery

would so soon and permanently enter the field of therapeutics in the treatment of consumptives.

Today, in the light of further evolution, the rulings referred to must seem antiquated and unjust, depriving these patients, if without financial means, of prompt and proper surgical help, probably the only help that will save life. For there are few hospitals that are in a position to assume the financial burden of providing a special room or rooms or a small ward for the treatment of these patients, which would involve special nursing and special employees to bring the food to the patients, not to speak of the special cleansing, a special set of orderlies, etc.

But the same hospitals admit to their surgical wards without question all types of emergency cases, such as acute appendicitis or cholecystitis, strangulated hernia, acute intestinal obstruction, etc. Nobody thinks of first looking for tubercle bacilli in their sputum, and should such be found later on, these patients remain where they are just the same and just as long as the case requires. There certainly is at present a glaring inconsistency in the laws governing the admission of patients to the wards of our hospitals.

In the light of modern teaching it seems to me a great wrong to persist in treating patients with tuberculosis bacilli in the sputum as outcasts who have to be isolated, although they have been thoroughly trained in expectorating into cups that are collected daily and burned. Much more reasonable would it be to isolate patients with acute pneumonia, with pneumococci in their sputum, or with influenza, with streptococci and staphylococci, etc., in their expectoration. Of course, there can be no question nor discussion that it would be ideal if all these patients with acute and chronic (specific) inflammation of the lung could be treated in special rooms or wards set aside for this purpose. Hospitals that can afford this and which are proceeding thus at present should continue to do so by all means.

But what interests us is to know: Is such isolation essential, is it peremptorily necessary in order to preserve the health of others?

The question to be determined thus would seem to be: Is an adult consumptive with positive sputum a menace to his neighbors in the ward during the comparatively brief period of postoperative treatment?

It should be emphasized here that the question of the advisability of admitting patients suffering from pulmonary tuberculosis to the *medical* wards of our hospitals is totally outside of this discussion.

Observations made in tuberculosis sanatoriums or in special tuberculosis hospitals have shown that there is hardly a single case on record in which a healthy physician, nurse or employee has contracted tuberculosis. There evidently does not exist infection from adult to adult, as far as the tubercle bacillus is concerned, except perhaps now and

then in cases of prolonged exposure, as in husband and wife. On the other hand, we all know that infection of children from tuberculous patients does take place. A greater susceptibility to contract tuberculosis evidently exists in the growing organism than in the mature. Therefore, it does not appear wise to have the tuberculosis afflicted mother, in the midst of active disease, in contact with her children. It appears right and proper to warn consumptives never to kiss the lips of a child.

It is necessary to enlighten the public properly in this respect, to tell them of the possibility of direct infection of a child by the tubercle bacillus and of the great improbability of a healthy grown person becoming afflicted with the disease in consequence of an even prolonged contact with consumptives. Such teachings would allay the fears that patients in the wards may entertain at the present time, if they hear that a patient suffering from tuberculosis of the lungs is with them.

The operative treatment of pulmonary tuberculosis is as yet new teaching for many members of the medical profession, still more so to the public at large. The interest and attention of both with reference to this great advance in surgery must first be thoroughly aroused. Phthisical patients are not yet applying for surgical help of their own accord. The material for operation, therefore, is still scant, although thousands and thousands are in dire need of operative help. But once the fundamental principle has been fully grasped and understood, there is no question, that there will everywhere be a flood of these cases. And, as has been stated, these patients should not be denied the surgical help they need as their last chance, nor should they be compelled to travel long distances to find a hospital and a surgeon prepared to render the required help.

In view of existing conditions and the obstinate and continuous obstruction I myself have encountered for the last fourteen years in my efforts to extend surgical assistance to patients suffering from intractable pulmonary tuberculosis in the wards of the hospitals with which I was actively connected as attending surgeon—the obstruction being based on the ruling of the Board of Charities of our state—it was decided to try to have this ruling changed. Hence, last summer, after my return from the annual meeting of the American Association for Thoracic Surgery at Rochester, Minn., the inspiring impressions of the symposium on the surgical treatment of pulmonary tuberculosis being still fresh in my mind, I addressed the National Tuberculosis Association (June 21, 1924) and requested them to assist in having this ruling of the Board of Charities of the State of New York modified or set aside. The board has sole legal authority in these matters in institutions which are "in receipt of public funds, which includes all money raised by taxation

whether from state, county, city, town or village." The ruling in question, which was adopted in 1910 and became effective Jan. 1, 1911, originally read as follows:

> Rule 20: No patient shall be retained at public expense in any hospital, wholly or partly under private control, unless provision is made for such patient as follows:
>
> C. In the case of patients afflicted with tuberculosis, in wards completely segregated from any and all wards occupied by patients not having that disease.

This ruling was modified in 1923 to read:

"In the case of patients admitted for the treatment of tuberculosis in rooms or wards completely segregated, etc."

After some correspondence and much delay, the final answer from the State Board of Charities at Albany arrived under date of Jan. 21, 1925. It was addressed to Dr. H. A. Pattison of New York City, supervisor of medical service of the National Tuberculosis Association, who had conducted the correspondence with the board. It read:

> At a meeting of the board's committee on medical charities, held at this office yesterday, the committee again considered carefully your letter of November 25 regarding a possible modification of Rule 20, C, of the rules of the board governing the reception and retention of patients in hospitals. . . . The committee also considered in the same connection replies which had been received from a number of superintendents of hospitals and sanatoriums with respect to the desirability of a modification of the rule just mentioned. The committee directed me to inform you that it is of the opinion that a modification of this rule respecting the care of tuberculosis cases is not desirable at present.
>
> I was requested to say further that the committee believes that in practically all general hospitals patients having pulmonary tuberculosis who may be admitted for necessary surgical procedure can be cared for in isolation rooms or cubicles and thus segregated from other patients not having this disease.

Special reasons for this decision were not given. Thus we were as far as we had been before.

I understand that some of our hospitals ignore this ruling and simply admit consumptives in need of surgical help to their wards. But their procedure is clearly against the law as long as they are in regular receipt of public funds. To my mind it seems better and wiser to remain "within the law" and convince the authorities of the states in which these rulings still exist that, in the light of modern knowledge and scientific facts, they have become obsolete and untenable. This all the more as the response to a circular letter sent out by Dr. S. Adolphus Knopf, the well known phthisiologist of New York City, whose interest and active cooperation in this matter I was fortunate enough to enlist, has shown that of thirty-eight states of our forty-eight from which replies were received, only four have this ruling today.

At all events, the answer of the New York State Board of Charities just referred to has been the immediate cause for submitting this matter for discussion to our association, which is national in scope, with a membership embracing all specialists interested in the study and treatment of thoracic diseases. It is hoped that a thorough discussion of the question by this body, from every possible angle, will sufficiently clear the atmosphere to induce the authorities of the various states in which the ruling exists to modify it, if not to repeal it once for all.

In this respect it seems auspicious that the writer of the letter from the Board of Charities of the State of New York in concluding his letter to Dr. Pattison, particularly stated:

> May I add that the board is still open minded in its attitude toward the question you raise, and would be pleased to receive and consider any further statement which you may wish to make, if you still believe that the existing rule is undesirable.

Since this paper was written, at the end of March, matters have taken a turn for the better in New York. Six weeks ago, March 23, I was informed by Dr. Pattison that the Board of Charities "had deemed it advisable to appoint a special committee of the board to confer with those most interested, in the belief that such a conference might result in an arrangement that would be satisfactory to all concerned." A few days later I received an invitation to be present at this meeting. I attended and we all had the chance to express our points of view of the question at issue. The members of the committee appeared most responsive and inclined to recommend to the board what we requested.

A few days before I left New York for this meeting, I received a letter from Dr. Pattison to the effect that, at a meeting of the Board of Charities held at Albany, April 21, the rule in question was amended substantially as agreed on at the conference. The portions of Rule 20 applying to the care of the cases of pulmonary tuberculosis now read as follows:

> No patient shall be retained at public expense in any hospital wholly or partly under private control unless provision is made for each such patient as follows:
>
> C. In the case of patients admitted for the treatment of pulmonary tuberculosis, in rooms or wards completely separated from any and all wards occupied by patients not having that disease. This shall not apply to adult patients admitted for the surgical treatment of pulmonary tuberculosis. Such patients, if cared for in wards, shall be separated from other patients by a cubicle or screen.

This means that, as far as the surgical treatment of consumptives is concerned, our public wards will from now on be open to these patients the same as to any other sick person, a wonderful advance for thoracic surgery in our state.

Let us hope that as a result of this decision of the state Board of Charities of New York and our discussion here today, the members of the boards of other states in which the objectionable ruling still exists will promptly follow the example set by their enlightened colleagues in New York.

All that now remains to be done seems to be to instruct the public at large through the proper channels that infection of a healthy adult from a consumptive on the basis of a brief, even close, contact with him need not be feared. Such information will allay apprehension on the part of the other patients in a surgical ward when a consumptive in need of surgical help is admitted for operation.

DISCUSSION

Dr. Edward W. Archibald, Montreal: Dr. Stewart's paper has been extremely interesting, but in the short time at one's disposal it is impossible to do more than touch on certain of the points he has brought forward.

The plates he has shown, illustrating the possibility of a spontaneous clearing up of acute, exudative lesions in the course of a comparatively few months, are most instructive and he and I have had occasion to take advantage of this fact in coming to a decision to operate on one of his patients. We postponed operation for a number of months, expecting that the acute, exudative lesions would clear up, and when they did so we were able to proceed with a thoracoplasty, which was thoroughly well borne. I have had several patients brought to me for operation, showing clear evidences of activity, sometimes in the worse lung alone and sometimes in the good or better lung as well. I have operated on one of the latter type, in which the extent of the lesion in the good lung was slightly although definitely active, hoping that the setting at rest of the worse lung might have a beneficial effect on the active process in the other lung (as one sees in some pneumothorax cases); after finding this patient immediately go bad with a spreading tuberculosis in the good lung, as determined by the history, physical examination and roentgen rays, it is better to postpone operation. Such patients are more apt to do well with medical treatment. If the lung picture clears up, they can later have their thorocoplasty with but little risk. If they do not clear up it is sufficient evidence to me that thoracoplasty would not have prevented the progress of the disease.

Dr. Stewart voices some opposition to either the cutting or the cauterizing of intrapleural adhesions, which are preventing a possible collapse of the lung in pneumothorax, and he reports one case in which he obtained a permanent collapse of a cavity by stretching the adhesion. I may be willing to allow Dr. Stewart, with his knowledge and his skill, to attempt the stretching of such adhesions, but as a general rule I am strongly against any attempt to collapse cavities by stretching adhesions through an increase of the intrapleural gas pressure. I think that any such adhesions, overlying a cavity, are attached to its wall and are, indeed, the direct result of the infection proceeding from that cavity. Sometimes the cavity is prolonged into the base of the adhesion, and I have seen such an adhesion, under the strain of coughing, with a moderate pneumothorax, pull open the cavity, with death in a few weeks from pyopneumothorax. I am strongly in favor of opening the chest and tying off the adhesion under direct inspection, with cauterization of the stumps. In two cases I have seen the underlying cavity, which was quite large, disappear

under a total pneumothorax, within a few weeks. If the adhesion is too dense or widespread, or too short, one can always close the wound, and no harm is done; indeed, I was obliged to do this on two occasions. In such cases the pneumothorax should be given up and a thoracoplasty done later.

As to phrenicotomy, my present opinion is that it should be reserved for special indications. Some are taking it up as a routine preliminary procedure to a thoracoplasty. There is no objection to it on the score of being a difficult or dangerous operation; but I feel that to make it a routine procedure would amount to doing it frequently without use or value. After a thoracoplasty including the eleventh rib, the diaphragm moves little, as I have observed frequently in screening patients weeks after their operation. The excursion of the diaphragm is reduced to about one-fourth or one-half inch (1.27 cm.), and the lower ribs do not expand much with respiration. I reserve phrenicotomy for lower lobe lesions, or for cases of trouble in the good side when one is doubtful whether the good lung will stand the strain of a thoracoplasty.

As to apicolysis, I have used it so far only as a third operation, to supplement a thoracoplasty for residual apical cavities. If the lung has extensive cavities and the patient is toxic, I am so afraid of it that I will not do it. If the lung is fairly good and the general condition of the patient satisfactory, I am prepared to do it, but only as a supplementary operation. There must be few cases in which an apicolysis is to be done as a sole and independent operation. A chronic apical cavity, without any disease below the apex, is a rare thing. Ordinarily speaking, a partial pneumothorax over the lower lobe and a thorocoplasty over the upper will be sufficient to safeguard such patients, and nothing less ought to be attempted.

I welcome Dr. Stewart's remarks on the saving of time in treatment, which is made possible by earlier diagnosis and an earlier use of pneumothorax. There is no doubt in my mind that many cases are allowed to drag on long after a pneumothorax ought to have been tried, and when that is once tried it is kept up long after it should have been abandoned in favor of a thoracoplasty, either total or partial. Patients are constantly coming to me, who, from their history, would have had a much better chance with operation if they had been referred a year or two previous, and I cannot help but feel that the medical man sometimes gets into a state of mind of "laissez aller," a sort of indeterminate, halfway state of mind that realizes the probable uselessness of further sanatorium treatment but has too great a fear of operative treatment.

Dr. Carl A. Hedblom, Madison, Wis.: I believe that the surgical treatment of unilateral pulmonary tuberculosis will receive a great deal of consideration in this country during the next five or ten years, and that it will be widely adopted. For this reason it is of great importance to determine as far as possible whether or not tuberculous patients may be housed in open wards during the course of such surgical treatment.

The opinions cited seem to me weighty and authoritative. I should attach especial importance to the opinions of those who have had a great deal of experience in the prevention and treatment of pulmonary tuberculosis and of those who are in intimate contact with laboratory procedures and investigations. But I fail to see how a surgeon who has not had opportunities for an extensive first hand experience with tuberculosis can have any basis for independent scientific judgment in the matter.

I therefore stand by my statement in reply to Dr. Knopf's questionnaire. The intent of my statement was that I saw no reason why a patient with tuberculosis bacilli in the sputum and who was to have or had had a thoraco-

plasty operation should be treated differently from a tuberculous patient with bacilli in the sputum and who had had some other operation or no operation. The crux of the question is whether or not a patient who has tuberculosis bacilli in the sputum can be housed in an open ward with safety to other patients. The answer to that question it seems to me should be the result of scientific inquiry rather than unsupported opinion. I am glad the subject has been brought up for discussion at this time because of its importance to progress in the surgical treatment of pulmonary tuberculosis.

Dr. Wyman Whittemore, Boston: I realize how fortunate I am to live in Boston, because at the Massachusetts General Hospital we seem to have had for a number of years a sensible board of trustees, also a sensible executive committee. Five or six years ago I made a simple written request that the executive committee allow us to take in these patients. Without any trouble they agreed to do it. Since then we have taken the patients in and operated.

Dr. Knopf spoke of the danger of aspiration pneumonia in performing the operation for thoracoplasty. My experience is limited in comparison with Dr. Archibald's; it is presumption on my part to speak at all about it. I have performed only twelve operations, yet in none of these cases have I experienced any such symptoms as might be attributed to aspiration pneumonia.

The position on the dangers of aspiration pneumonia taken by Alexander in a recent article that you are all familiar with, seemed to me somewhat exaggerated and I was glad to hear Dr. Archibald state that he felt much the same way.

Dr. Philemon E. Truesdale, Fall River, Mass.: I also live in Massachusetts. I believe that there is probably about the same chance of enforcing this law in Massachusetts as there is at present of enforcing the Eighteenth Amendment. It seems to me that wherever this law exists it must be winked at because it is not reasonable to exclude from hospitals patients with pulmonary tuberculosis who have other lesions in the body requiring surgical intervention. For example, a patient suffering from an incipient tuberculosis or from tuberculosis in a moderate stage of advancement may have gastric ulcer or stenosis of the pylorus, conditions which in many ways are aggravating the tuberculous process and occasionally make operative measures imperative to save life. Patients with pulmonary tuberculosis also may have distinct surgical lesions elsewhere demanding surgical intervention. Must these operations be done always in a tuberculosis hospital? No; these patients should be taken to a general hospital and operated on there.

Among others of this class are patients with tuberculous salpingitis and incipient pulmonary tuberculosis. They are operated on for tubal disease in a general hospital. Patients with tuberculosis of the kidney and incipient tuberculosis are operated on for tuberculosis of the kidney in a general hospital. Why should this particular operation of thoracoplasty exclude the tuberculous patient or patients with pulmonary tuberculosis from the general hospital? To do so does not appear to be rational or fair to the patient.

Dr. Willy Meyer, New York: I shall add only a few words, as we still have an important subject before us for discussion. Why are patients suffering from pulmonary tuberculosis in need of operation excluded from the general wards of our hospitals up to this day? Because the general public was warned at the time when the National Tuberculosis Association was founded that segregation was the principle thing to avoid a spread of the disease. We know better now. Of course, we are speaking here only of surgical patients who are afflicted with pulmonary tuberculosis.

The patients in the wards do not care if another patient in the ward operated on for tuberculous nodes of the neck, or a tuberculous knee, or a tuberculous salpingitis and peritonitis, coughs and expectorates, and his sputum probably contains plenty of tubercle bacilli. But when the same patients in the ward hear that a patient with pulmonary tuberculosis has been admitted, they get frightened and many of them probably leave. What is the reason? Because the public is wrongly educated in this subject. It is certainly a most important point that those who are charged with proper public education should tell the people the true state of affairs, viz., that direct infection from adult to adult in consequence of a brief mutual confinement in the same ward does not occur. An individual physician cannot state these facts in the public press, but officers of the National Tuberculosis Association have the right to go into the newspapers and instruct the public properly and correctly.

In regard to aspiration pneumonia subsequent to thoracoplasty, it is certainly interesting that the originator of the extrapleural thoracoplastic operation, Brauer, of Hamburg, today favors the one stage operation and does it himself in one stage. I myself believe that if there is a cavity of some size in the upper lobe of the lung the two stage operation, under regional and local anesthesia, will be the safer procedure for the patient.

From a general point of view these patients should not be obliged to travel hundreds of miles in order to find a hospital where they can have this operation done. In every state there should be one or more surgeons competent to do it and prepared to conduct the after-treatment properly.

THE PLACING IN GENERAL SURGICAL WARDS OF PATIENTS ON WHOM THORACOPLASTY HAS BEEN PERFORMED

REPORT FROM TUBERCULOSIS EXPERTS AND STATE HEALTH BOARDS *

S. ADOLPHUS KNOPF, M.D.
NEW YORK

The more and more gratifying results obtained in late years from thoracoplasty in far advanced cases of pulmonary tuberculosis has created the desire to give the benefit of such surgical treatment to the consumptive poor as well as to the rich, but in the state of New York a serious obstacle has been met with in the law which forbids tuberculous patients to be admitted into the surgical wards of the general hospital. This law was enacted some years ago on the recommendation of the state board of charities.

Dr. Willy Meyer called on me recently wishing to ascertain my personal opinion on the alleged danger of spreading the disease when a tuberculous patient on whom thoracoplasty has been performed is placed in the surgical ward of a general hospital. I felt then, as I feel today, that I could answer this question by saying that in the well conducted, sanitary hospital of today there is no danger whatsoever to adults. But in such a vital matter as this I believe one man's opinion should not count for much and I promised Dr. Meyer to collect the opinions of some of our leading tuberculosis specialists and sanitarians on the subject. For this purpose I addressed the following question to each of the names selected as authoritative and representative:

Does any danger arise to patients suffering from other diseases when a tuberculous patient who has been operated on by means of extrapleural thoracoplasty, for rib resection or cutting or avulsion of the phrenic nerve, is placed in a corner of a surgical ward of a general hospital?

In reply to this inquiry, Drs. Edward R. Baldwin of the Trudeau Sanatorium; Sherman G. Bonney of Denver; Kennon Dunham of Cincinnati; Charles J. Hatfield of Philadelphia; Maurice Fishberg and James Alexander Miller of New York; George M. Kober of Washington; Allen K. Krause of Baltimore; Walter J. Marclay of Minneapolis; Charles L. Minor of Asheville; Edward O. Otis of Boston; F. M. Pottenger of Monrovia; Joseph H. Pratt of Boston; E. Richmond Ware of the Barlow Sanatorium, Los Angeles, and William Charles

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* Read by invitation before the American Association for Thoracic Surgery, Washington, D. C., May 5, 1925.

White of the U. S. Public Health Service, stated their entire agreement with me. The last named even added the following significant words: "I would strongly urge the elimination of all such expressions as *placing in a corner surrounded by a screen or cubicle;* this only postpones the day of beneficial care of those afflicted with tuberculosis."

It might be interesting to note all the additional comments that were made on the situation, but I will only quote a few. Dr. Baldwin said: "You have hit on a very real problem in the modern treatment of tuberculosis and I confess it is a puzzling thing to work out. As you know, there is a great deal of hypocrisy in this matter of hospital treatment of tuberculosis, or for that matter also in hotels, both in country and city." Dr. Dunham said: "You are bringing up a very timely and important subject and I am glad to give it all the support within my power." Dr. James Alexander Miller said: "In my opinion, a good many of these rules about taking tuberculous patients in general hospitals are antiquated and not in line with modern medical knowledge."

Dr. Allen K. Krause of Johns Hopkins University, the editor in chief of the *American Review of Tuberculosis,* whom we consider one of our best authorities in his specialty, wrote as follows: "I do not see how a patient with pulmonary tuberculosis who has undergone a surgical operation can be dangerous to his neighbors in the wards of any hospital that is being administered according to present standards of hygiene and the ordinary precepts of modern care and sanitation of the sick. For such a person to put other patients in jeopardy requires conditions that would arise out of incompetent management of the institution."

Lastly, may I mention the expert opinion expressed by no less a person than the president of the National Tuberculosis Association and head of the Henry Phipps Tuberculosis Institute of the University of Pennsylvania, Dr. Charles J. Hatfield, who wrote to me as follows: "I am strongly of the opinion that there is no danger whatever to adult patients in the surgical ward of a general hospital from the admission of a tuberculous patient operated on for thoracoplasty. I am quite willing to have this opinion quoted."

Of the many courteous replies coming from the secretaries of the state boards of health, many of whom are distinguished sanitarians and also tuberculosis experts, I wish to quote a few of the most striking sentences that they added to their reports as personal opinions:

Dr. S. W. Welch, state health officer of Alabama, wrote: "The public phobia in regard to these unfortunate patients is unfortunate, and for the most part groundless." Dr. F. T. Fahlen, state superintendent of public health of Arizona, wrote: "Five years ago I developed an ugly, acute appendicitis, was operated on, and made a slow recovery. This operation was done in a hospital filled with tuberculous patients

and I feel morally certain there were quite a number of tubercle bacilli floating around all the time. I did not develop tuberculous peritonitis." Dr. C. W. Garrison, state health officer of Arkansas, wrote: "There are no laws in this state governing the admission of tuberculous patients in surgical wards of general hospitals. Each hospital management regulates the admission and policies. Our great handicap in this state has been to secure adequate hospitalization for emergency surgical cases." Dr. Tracy R. Love, secretary of the state board of health of Colorado, wrote: "We, in Colorado, feel that the hospitalized patient with tuberculosis is less a menace than the one that is on the street. We have had patients on whom thoracoplasty has been performed, and these patients have then been allowed to have beds in a surgical ward and it was not even deemed necessary to keep screens around them. Furthermore, we do not hesitate to allow patients with active tuberculosis to have ward beds when, for any reason, surgical interference has been necessary." Dr. William F. King, state health commissioner of Indiana, wrote: "It seem to me that a regulation of this kind is unnecessary and there would be no danger of transmitting tuberculosis to other patients in a ward except through the most reprehensible and criminal carelessness." Dr. Oscar Dowling, president of the Louisiana state board of health, wrote: "I thoroughly agree with you that there is no valid reason why patients who have been subjected to a thoracoplasty should not be admitted to the surgical ward of any hospital." Dr. C. F. Kendall, state commissioner of health, Maine, wrote: "I have no hesitation in answering that, in my opinion, there is no danger whatever if a screen is placed between the tuberculous patient and the other patients, and if the attendants remember the precautionary measures that any well trained nurse would be likely to observe." Dr. James Stewart, state health commissioner of Missouri, wrote: "I personally feel that there is but the remotest danger in the transmission of tuberculosis to other patients and attendants, provided, of course, that the well established principle of hospital ward technic is carried out." Dr. W. H. Wilson, chief of the Nebraska bureau of health, wrote: "My personal opinion is that tuberculous patients taken into hospital wards to be operated on by thoracoplasty are entirely free from danger to other inmates, provided the proper sanitary precautions are carried out, as they should be in any case of tuberculosis admitted in a general hospital." Dr. Charles Duncan, secretary of the state board of health of New Hampshire, wrote: "We see no reason why tuberculosis cases of this nature properly handled should not be received in hospitals conducted for surgical cases." Dr. H. B. Costill, director of health of the state of New Jersey, wrote: "I understand that many of our hospitals are admitting to surgical wards tuberculous patients, and our men claim

that they have found no ill results from so doing." Dr. G. S. Luckett, director of the bureau of public health of New Mexico, wrote: "It seems to me that the demonstration has been rather convincing that the use of cubicles and attention to strict asepsis will prevent cross infections." Dr. R. G. Leland, chief of the division of hygiene of the state of Ohio, wrote: "I can, without reservation, indorse the opinion of the leading experts in tuberculosis mentioned in your letter, that there is no danger of infection to other patients in a general hospital arising from a tuberculous patient in a surgical ward." Dr. W. G. Turnbull, deputy secretary of health of Pennsylvania, wrote: "I would consider the passing of such a law or of such a regulation as an admission that we have been teaching erroneous doctrines in the past. If we admitted that we cannot take such care of a tuberculous patient confined in a hospital bed that he will not be a menace to those around him, we are wasting time trying to teach doctrines of this sort to ambulatory patients who are taking care of themselves." Dr. B. U. Richards, secretary of the Rhode Island state board of health, wrote: "It occurs to me that the term 'room' might be interpreted rather liberally. I am not at all certain, but a part of a ward made separate by the use of screens might legally be interpreted as a room by itself. If the matter should come up for interpretation here in this state, I should certainly try to get away with it." Dr. James A. Hayne, secretary of the state board of health of South Carolina, wrote: "As far as admitting tuberculous patients operated on by thoracoplasty to the surgical ward of a general hospital, I agree with Dr. Nicoll that the chances for infection are so limited that I do not see why they cannot be admitted to the surgical wards." Dr. E. L. Bishop, commissioner of public health of Tennessee, wrote: "In my judgment, the danger to other patients would be remote." Dr. T. B. Beatty, state health commissioner of Utah, wrote: "I cannot conceive of any danger provided ordinary precautions are taken." Dr. C. A. Harper, state health officer of Wisconsin, wrote: "Such procedures are left to the hospital trustees or governing body. It has been practically the universal practice for a great many years to admit tuberculous patients needing surgical care to any and all medical and surgical hospitals in the state. I know of no hospitals in which there is a bar against such procedures. I can hardly conceive of a remote danger to other patients and attendants by such procedure, especially when ward and hospital technic is conducted according to the well established principles of sanitation." Dr. G. M. Anderson, state health officer of Wyoming, wrote: "It is my opinion that very little danger arises to the patients suffering from other diseases when a tuberculous patient who has been operated on by means of extrapleural thoracoplasty is cared for properly in a ward where there are other patients of a nontuberculous

character. There can arise very little danger of their contracting tuberculosis."

Instead of giving any further quotations from the tuberculosis experts and the opinions of state health officers, I will now quote from a letter received from Dr. Matthias Nicoll, Jr., the distinguished state commissioner of health of New York, as follows: "I need hardly say to you that in my opinion there is but the most remote danger, and one hardly conceivable, of transmitting tuberculosis to other patients and attendants by such a procedure, provided ward technic is conducted according to the well established principles of sanitation."

Dr. Linsly R. Williams, the managing director of the National Tuberculosis Association, writes: "I am heartily in accord with the resolution adopted by the National Tuberculosis Association in 1916 which urged that there be special tuberculosis wards in general hospitals. This we have always felt was a wise and necessary measure for properly caring for cases of tuberculosis. I believe that there is no danger of contracting tuberculosis from patients affected with that disease in well conducted hospitals or sanatoriums. I know, however, that there are many hospitals and sanatoriums which are not conducted as well as they should be from the point of view of prophylaxis." To this objection, if it may be considered such, I can only reply that in a badly conducted general hospital there is just as great a danger of propagating other infectious diseases, such as syphilis, gonorrhea, pneumonia, streptococcic infections, etc., as tuberculosis, and such instiitions have no right to exist.

However, Dr. Bowditch of Boston, a well known tuberculosis expert, does not believe that a movable screen in a corner of a surgical ward is sufficient protection against infection. He then speaks of the unwritten law in Boston that tuberculous patients shall not be admitted in the general hospitals.

According to the information received from Dr. Eugene R. Kelly, the commissioner of public health, there is no state law in Massachusetts prohibiting the admission of a tuberculous patient on whom thoracoplasty has been performed to the surgical ward of a general hospital. Dr. Joseph H. Pratt of Boston wrote to me that he had had patients in general surgical hospital wards for thoracoplasty. Dr. Frank Billings of Chicago, the well known internist, is most strongly opposed to the idea, and answered as follows: "So far as I know there is no regulation or law in Illinois to prevent the treatment of a patient with pulmonary tuberculosis in a ward with other patients. However, it is not done and I am of the opinion that it would be a dangerous precedent to establiish, for while proper precautions would be made in some institutions, it is most likely that carelessness would follow in others." Dr. Billings is mistaken, however, when he says there is no regulation or

law in Illinois concerning this matter. Rule 5 in the newly revised Rules and Regulations for the Control of Tuberculosis in the State of Illinois reads as follows:

"No person suffering from active or open tuberculosis, as defined in Rule 3, shall occupy the same room as a bedchamber or sleeping room with any other person or persons unless such person or persons are suffering also from the same form of tuberculosis. This rule does not, however, apply to well adult persons acting as nurse or attendant under the direction of a legally qualified physician."

Dr. George M. Kober of Washington is of the opinion that we should not lose sight of the psychic effect of such cases on patients in the wards who are suffering from other diseases or injuries. He considers the decision of the state board of charities of New York, arrived at several years ago (1909), quite proper, but believes that a properly constructed cubicle with a sheet as door would allay all fears that might arise in the minds of the other patients.

Dr. Meyer was not quite content with my having these expressions from tuberculosis experts but wished me also to tell him how many states in this country have a law similar to this one in New York. Not being able to answer this offhand, I wrote to the state health officers of the forty-eight states and of the District of Columbia. I explained the condition in the state of New York and asked the direct question whether there was any law in their states prohibiting the admission of tuberculous patients on whom thoracoplasty has been performed to the surgical wards of general hospitals. The commissioners or state health officers of the following states most courteously replied with the decisive answer that there was no law in their states prohibiting a tuberculous patient operated on for no matter what cause from being admitted into the surgical ward of a general hospital: Alabama, Arizona, Arkansas, California, Colorado, Connecticut, Delaware, Georgia, Idaho, Indiana, Iowa, Kansas, Kentucky Louisiana, Maine, Maryland, Massachusetts, Michigan, Mississippi, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, North Carolina, North Dakota, Ohio, Oklahoma, Oregon (except in the city of Portland), Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Utah, Vermont, Washington, West Virginia, Wisconsin, Wyoming.

All the forty-nine letters addressed to state boards of health were answered. The states of Illinois, Minnesota and Virginia, the District of Columbia and the city of Portland, Oregon, are the only ones besides New York reporting the existence of prohibitory laws. It is interesting to note that two of the four having such antiquated laws have a right to boast also of having in their midst some of the largest surgical centers of the country. I refer to the state of Minnesota, made famous by the great work of the Mayo brothers, and the state of Illinois with its splendid medical schools.

The state of Virginia has the strictest law of all those which prohibit tuberculous patients that have been operated on from being placed in surgical wards with nontuberculous patients. In this state any person violating the law shall be "deemed guilty of a misdemeanor, and, on conviction thereof, shall be subject to a fine not to exceed $50 for each offense." A strong letter favoring such a law came from the state of Minnesota. I quote from this lengthy letter sent to me by the executive secretary of the Minnesota advisory commission for consumptives, Dr. Robinson Bosworth, as follows: "It is our opinion that present regulations requiring pulmonary tuberculosis cases to be placed in rooms or in wards for their exclusive use is wise and reasonable. . . . Patients who are tuberculous should not be placed in rooms or wards containing nontuberculous patients. We see no good reason why an exception should be made of a thoracoplastic case." Yet Dr. A. J. Chesley, the secretary and executive officer of the state board of health of Minnesota, says: "My impression is that in spite of the section of the statutes quoted, the opinion of the most advanced medical men is that it is safe to treat tuberculosis cases of the type mentioned in your letter of March 21 in the surgical wards of the general hospital."

The thoracic surgeons with whom I communicated are almost unanimously of the same opinion. Dr. Hedblom, however, gave his opinion as follows: "My position in the matter would be that as long as the patient is raising sputum containing the tubercle bacilli the same rules would apply to him as to a patient who has had no operation." Those of us who are responsible for early diagnosis never wait for its confirmation by the presence of the tubercle bacillus to take precautionary or curative measures. When the physical signs and symptoms, aided if possible also by the roentgen rays, strongly indicate the presence of tuberculosis, all precautionary and curative measures are immediately installed. We also must bear in mind that when the patient has a great deal of bronchorrhea many specimens will often be required before the tubercle bacillus is found. At all events, if we should have to consider the patient on whom thoracoplasty has been performed as a possible source of infection and did not find the bacillus prior to or immediately after the operation, this could not be a decisive factor.

Another objection to admitting tuberculous patients to our general surgical wards comes from the distinguished thoracic surgeon, Dr. John Alexander of Ann Arbor, Mich., now at Saranac Lake, who says: "As a paravertebral thoracoplasty in advanced tuberculosis is a grave operation, I feel it incumbent on the hospital not to impose on any patient accepted for the operation conditions that are unfavorable to him. I consider it an unwise policy to bring a person with far advanced tuberculosis from a country sanatorium and coop him up in screens in a large surgical ward in which the room temperature and ventilation

are regulated for patients accustomed to urban living conditions and in which the usual day and night noises and atmosphere of excitement could be expected to have only a harmful influence on such a chronic invalid as a tuberculous patient immediately following an operation of the magnitude of thoracoplasty."

Dr. Alexander also says that we must consider the prevalence of phthisiophobia in the laity. I have been trying in a humble way to combat this exaggerated fear of the presence of a consumptive for a quarter of a century and was delighted to have found in our present movement a new weapon against it. In regard to Dr. Alexander's other objection, I might say that in our great cities the majority of our patients for thoracoplasty come from tuberculosis hospitals in cities where there are no such ideal climatic conditions as those under which Dr. Alexander would desire to have all tuberculous thoracoplastic patients placed. But even should some come from a place in the country, our surgical wards are usually well ventilated and quiet, and a screen near the open windows does not exactly mean cooping up a patient who is confined to bed anyway after his operation. Certainly this objection to city air would apply to a private room as well as to a ward.

Finally, I should like to ask Dr. Alexander if there are now, as he estimates in his admirable article in the *American Journal of Medical Science* (**168:** 1 [July]; 268 [Aug.]; 412 [Sept.]; 574 [Oct.] 1924), 15,000 persons with pulmonary tuberculosis in the United States for whom surgical interference is indicated, in how many instances these unfortunate 15,000 could be operated on in separate rooms or separate wards under such ideal climatic and sanitary conditions as he feels it incumbent to provide for all patients that have come to thoracoplasty.

Dr. Charles H. Peck of the Roosevelt Hospital, New York, replied to my letter as follows:

"Dr. Willy Meyer has recently brought the same question to my attention and asked to have our medical board express an opinion on the matter. Their reaction was rather unfavorable to asking for a change in the law. I think the feeling was that the psychic effect on patients in beds adjacent to that of a pulmonary tuberculosis patient would be quite as important as any actual danger, which they could probably be protected from.

"My own feeling is that if these patients are to be admitted to a general surgical ward, they should be, as you suggest, in a separate corner shut off from the general ward by a screen or cubicles (glass partition)."

I am glad, indeed, to report that in the state of New York, where the latter precaution is observed, we are now permitted, since April 21, to place tuberculous patients on whom thoracoplasty has been per-

formed in the surgical wards of our general hospitals. How was this accomplished when up to only a few months ago the New York state board of charities absolutely refused to change or modify the law which heretofore made it impossible to admit tuberculous patients into general surgical wards? The credit for this victory belongs primarily to the indefatigable efforts of Dr. Willy Meyer and, next, to the distinguished colleagues who sustained me in my humble opinion, and last but by no means least, to Dr. H. A. Pattison of the National Tuberculosis Association, to whom I showed all the letters I had received from our leading tuberculosis experts in this country and the numerous letters received from tuberculosis authorities at the head of the state boards of health, the majority of which stated emphatically that no danger to an adult nontuberculous patient should arise from the presence of a tuberculous patient operated on by thoracoplasty in the same ward. Dr. Pattison merely caused copies of all these letters to be made and submitted them, accompanied by a strong letter from himself, to the New York State Board of Charities. The special committee, composed of Dr. John Richard Kevin, as chairman, and Dr. Lee K. Frankel, Victor Ridder and William Rhinelander Stewart as members, considered all the evidence before them, and the result was a modification of the original law, quite satisfactory to all concerned.

May I say in answer to the fears expressed by Dr. Peck in regard to the psychic effect on patients in beds adjacent to the tuberculous patient that tactful explanation and the separation by screen or cubicle would allay all apprehension on the part of other patients.

A most interesting situation exists in the state of Oregon, according to the following reply received from Dr. Frederick B. Stricker, the state health officer: "There are no regulations in the state which prohibit the admission of tuberculous patients to hospitals but in the city of Portland there is a regulation that prohibits the hospitals of this city from taking any tuberculous patients. This measure was made some years ago in order to prevent the erection of a state tuberculosis sanatorium in the city of Portland. Many attempts have been made to have this pernicious ordinance removed from the books but so far our efforts have been in vain. Of course, you know that every hospital in this city is taking tuberculous patients and there is no way of stopping them, but still these laws make it possible for hospitals to refuse to take tuberculous patients, which is being done every day in the city of Portland. All the cases that are in the hospitals at the present time are under some other diagnosis. Your interest in this matter is certainly commendable and I trust that you will be able to gather information that will be of value in making it possible for tuberculous patients to enter all hospitals."

16 West Ninety-fifth Street.

POSTOPERATIVE GANGRENE OF LUNG WITH ENCYSTED EMPYEMA

OPERATION; RECOVERY

WILLY MEYER, M.D.
NEW YORK

Postoperative gangrene of the lung in a patient who is not afflicted with chronic pulmonary disease is almost invariably due to aspiration in the course of an operation done under general anesthesia. In some instances an infected thrombus thrown into the lung as an embolus may be responsible for it.

Aspirated material is either blood with mucus or pus, in operations in the mouth, nose or nasopharynx, tonsillectomy, etc., or stomach content. In the latter case it is due to vomiting during the surgeon's work, or after the completion of the operation while the patient is being returned to his bed, still under the influence of the anesthetic, or in bed as a result of inattention or improper handling by the attending nurse. The clinical pathologic sequelae are determined by the area within the lung where aspiration takes place, whether more centrally or peripherally located, the degree of virulence and the chemical composition of the foreign substance that passed through the larynx and the trachea with inspiration, and the quantity of the infecting substance.

A small amount of mildly infectious fluid that has entered a more centrally located area of the lung probably will produce a localized aspiration pneumonia, often followed by one or more acute abscesses, while the more massive aspiration of very infectious material, if the accident does not take life immediately, will create a far reaching acute gangrene of the lung. On the other hand, infectious stomach contents gradually drawn up with inspiration into the smaller bronchi will set up a more peripherally located gangrene of the lung which, as a matter of necessity, immediately or later, will involve the pulmonary pleura. The development of a general or localized (encysted, sacculated) empyema is the complicating consequence.

It is self-evident that all possible degrees of infection, from localized to diffuse and from mild to virulent, with a great variety of combinations according to localization, are met with.

A careful analysis of the symptoms and the application of all the modern means for refining the diagnosis will determine the physician's or the surgeon's decision as to what to do in the given case. That the situation is almost always a grave one is clear.

A man, aged 59, having a case of this type came under my care in May, 1924. He had been operated on for a strangulated hernia under ether by a competent surgeon in an out of town hospital in the middle of March. The wound had healed well, but the patient complained of pain in the right shoulder and lower right side of the back, with the frequent impulse to cough. These symptoms of a possibly existing pulmonary complication had set in shortly after he had come out of the ether. They were soon followed by fever. Catarrhal pneumonia was diagnosed. Two weeks after the operation the patient went home, but before long had to return to the hospital on account of general malaise and local manifestations. A few days after he had reentered the hospital, he suddenly coughed up a good deal of mucopus that had a foul odor. Roentgenograms taken at intervals revealed a rather diffuse infection of the right lung, and about six weeks after operation a cavity and fluid level could be made out. A lung abscess was diagnosed and operation was advised.

At this juncture the patient came under my care. Twelve years before I had operated on a relative of the patient for an advanced bronchiectasis by means of ligation of the respective branch of the pulmonary artery. This young man, cured today, insisted on my handling the case.

When the patient was admitted to our private hospital, he brought along the roentgenograms that had been taken in his town; they showed the characteristics mentioned. On clinical examination, percussion revealed dulness over the lower two thirds of the right chest posteriorly, but on auscultation only a few râles were heard. There was no amphoric breathing, no expectoration of any large amount of sputum, in many different postures tried; in short, clinically I found the almost negative status so often observed in bronchiectatics shortly after the bronchial tubes have been cleared. With forced coughing, some purulent sputum of extremely foul odor was brought up. This, it was stated, had occurred spontaneously several times daily in the course of the last few weeks, the attacks of coughing with a final scant expectoration always tiring the patient greatly.

Had the typical sweetish odor of gangrene of the lung not been missing, I should at once have diagnosed subacute gangrene with a localized empyema, supposing that the communication with the bronchial tree was within the upper half of the sacculated pleural abscess.

As it was we resorted to additional roentgenography and bronchoscopy. Dr. W. H. Stewart's report was in part:

Roentgenographic signs after examination of the chest point to a pus cavity lying on the right side between the sixth and the eighth ribs posteriorly (Figs. 1, 2 and 3). The lesion appears to be a pulmonary one rather than a sacculated empyema, although there is no just roentgenographic reason to make this diagnosis. One has to correlate the clinical, roentgenographic and laboratory presentations before this differential diagnosis can be made. Even then, some cases have pulmonary and pleural involvement. A needle entered posteriorly in the seventh interspace, about 6 cm. to the right of the spinous process will encounter pus.

The bronchoscopist, Dr. J. D. Kernan, Jr., reported that pus of a foul odor was discharged from the posterior branch of the right lower lobe bronchus. He expressed the opinion that it might be possible successfully to submit the cavity to intrabronchial treatment.

A symptom pointing against our dealing with an abscess of the lung was the rare and scanty productive cough in the presence of a clearly defined fluid level in a large cavity. Closed abscesses of the lung are extremely rare. They

are oftener seen in the beginning of an inflammatory trouble within the lung, during the formative stage of the abscess and the breaking down of the pulmonary tissue. As soon as they have reached a certain size and the primary acute infiltration around the focus temporarily sealing the broncheoli that lead to the respective area within the lung has begun to recede, while the pressure within the abscess cavity increases, they perforate into the bronchial tree and the surprised and frightened patient suddenly expectorates a large amount of foul pus. After a little while the majority of abscess cavities within the lung do communicate with the bronchial tree and at varying intervals empty themselves more or less, either spontaneously or by means of posture.

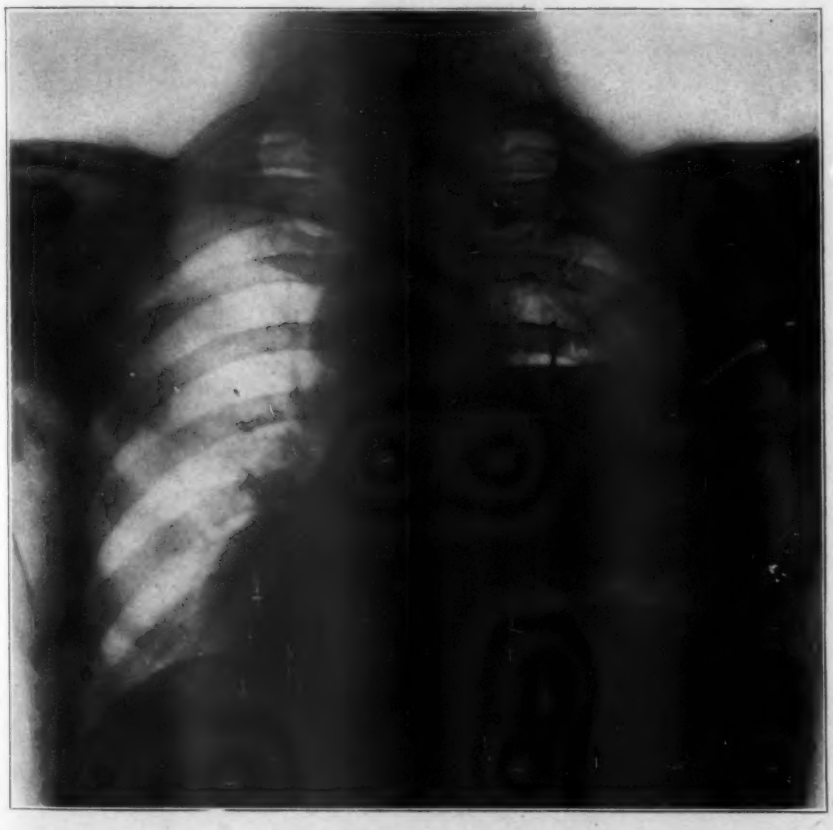

Fig. 1.—Patient in erect posture: distinct fluid level; lead markers in front for stereoscopic purposes.

When roentgen-ray examination has shown a distinct fluid level, this incongruity of the usual classical symptoms alone should make physician, surgeon and specialist at once think of something else than the mere presence of an abscess of the lung.

The only other alternative to pulmonary abscess in my case was a sacculated (encysted) empyema following an inflammatory focus in the lung (pneumonia) or rather a gangrenous pulmonary inflammation, in view of the foul sputum. The hooks of a hydatid were absent in the sputum. A suppurating

intrathoracic dermoid and an encysted, tuberculous cold abscess, both of which are usually of mediastinal origin, did not come into consideration, partially in view of the location of the cavity with a fluid level in the chest, and because of the clear history of preoperative perfect health and the absence of tubercle bacilli in the sputum. To assume that a symptomless, encapsulated cystic tumor should have become inflamed after operation under general anesthesia would have been rather far fetched.

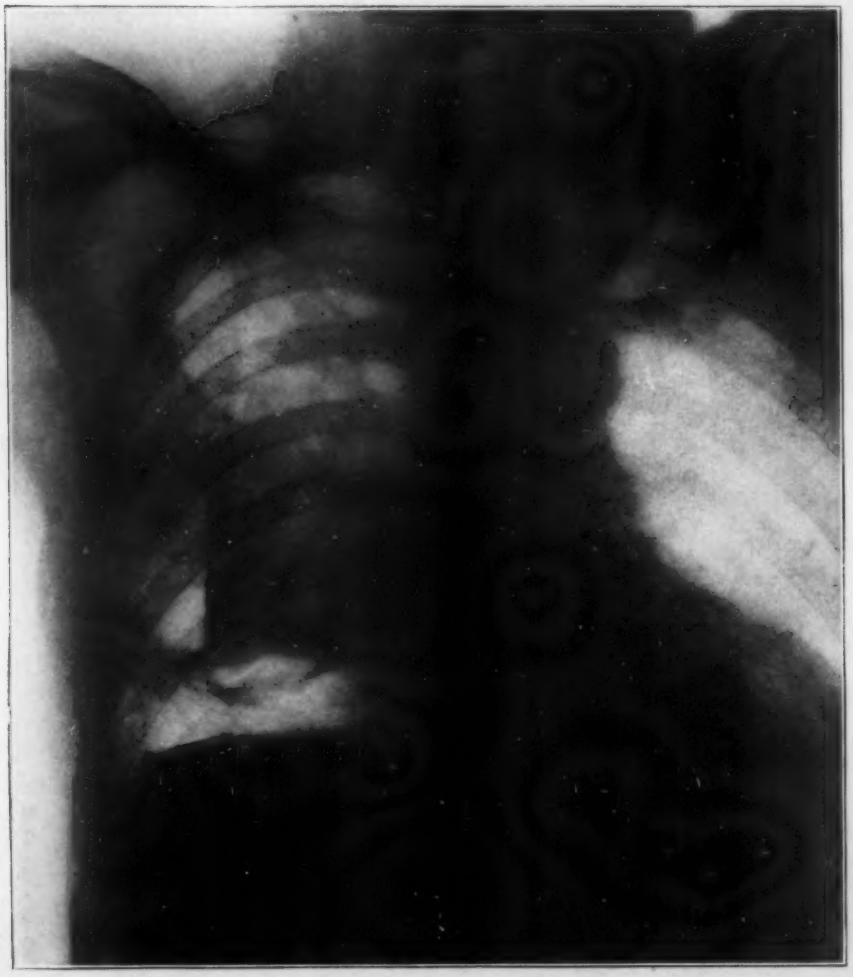

Fig. 2.—Patient in lateral horizontal position; picture is very similar to that of a lung abscess in both figures.

Radical operation appeared to be the proper course. That bronchoscopic treatment of the cavity also might bring relief could not be denied, but seemed less advisable. Moreover, the patient himself was in favor of prompt operation.

A long piece of the seventh and eighth ribs in the posterior axillary and scapular line was resected well beyond the angle, under local and regional anesthesia, May 20. When the periosteum was stripped off the seventh rib, pus was encountered. The bone was removed and the pleural rent enlarged sufficient for the introduction of the suction tube and evacuation of more than a pint of pus, and then the bed of the rib was incised under the guidance of the finger. This opened a clearly defined cavity—encysted empyema—in the

Fig. 3.—Lateral view of chest with patient on his back.

depth of which an encircling adherent portion of a gangrenous lung with multiple perforations was seen. The bridge between some of the superficially situated cavities was divided with the actual cautery; the lower deep border of the wound formed by the thickened periosteum with pleura was cut downward at right angles, so that two flaps were formed; thorough drainage by means of aseptic gauze tampons was established. The wound as such was left wide

open. The after-treatment was smooth without exciting experiences for either patient or surgeon. A few days after the operation the man was out of bed. With continuous good feeding, the use of blow bottles and open air treatment, the wound was definitely closed after three months. Today the patient is in perfect health (Fig. 4).

I have seen a number of cases of pulmonary postoperative gangrenous inflammation following aspiration, during or after general

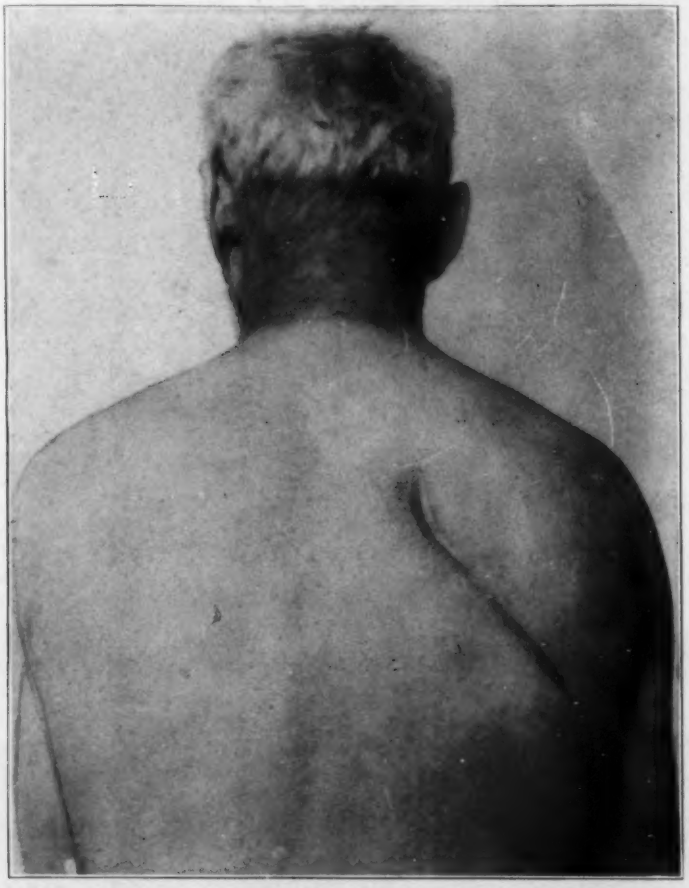

Fig. 4.—Final result.

anesthesia, in the course of years, but I shall mention only a few. First, I shall give extremes on either end of the line, the mild and the virulent.

A woman, aged 28, had local gangrene with sacculated empyema subsequent to an interval operation for appendicitis, under troublesome general anesthesia, in 1896. Before the proposed resection of the rib could be done, the pus perforated into, and was gradually expectorated through, a larger bronchus. There was spontaneous cure without annoying consequences.

A woman, aged 54, was operated on for cataract under general anesthesia, which was much disturbed, in 1922. Soon after the operation she had fever and pains in the chest, and coughed up extremely foul, sweetish sputum. The diagnosis was gangrene of the lung. When I saw her, there was local emphysema of the skin and symptoms of general sepsis. Despite the low general condition an operation was performed under local anesthesia. A large cavity was found, with total gangrene of a portion of the lung and many perforations. Gauze tampons were inserted and the wound was left open. The patient experienced extreme shock, which did not yield to any of the usual subcutaneous and intravenous stimulants. She died suddenly two hours later. Necropsy was not permitted.

I shall further briefly mention a few cases of other types of sequelae of threatening or fully developed gangrene of the lung and their treatment which have been previously referred to by me in public.

A young woman was seen early with aspiration after tonsillectomy and acute septic pulmonary inflammation. She had a continuous distressing cough, raised foul sputum, and had a high fever. A primary bronchoscopy with thorough aspiration of the secretion was performed by Dr. H. L. Lynah. Prompt disappearance of all symptoms and permanent cure followed. Here early intrabronchial treatment evidently acted as a prevention of the otherwise unavoidable advance of the process.[1]

A young woman, who had always been well before, had an ovarian cyst removed under general anesthesia. Aspiration occurred. An operation with rib resection had to be performed for a bronchiectatic abscess in the right upper lobe a few months later and prolonged drainage was instituted. Against advice the cavity was allowed to close by her home physician. The former symptoms soon returned. Another operation was performed and drainage again provided for. A lung lip fistula was formed. Later, there was complete closure of the wound and permanent cure.[2]

A man, aged 36, who had a cholecystectomy with appendectomy, suffered an attack of asphyxiation during the anesthesia. Acute gangrenous pneumonia of the right upper lobe followed. Bronchoscopy plus aspiration was done at the earliest possible moment, with the temperature still around 104. Soon roentgen-ray examination showed two cavities with fluid level. Regular intrabronchial treatment was given by Drs. H. L. Lynah and R. Jordan for eighteen months, which was followed by complete cure with recovery of the lung tissue. Today both sides of the chest are absolutely normal, as shown by roentgenographic examination.[3]

The principal point taught by the cases cited is the advisability of widening the field of local and regional anesthesia. Every surgeon should familiarize himself with the various methods. Still better, the

1. Meyer, Willy: New York State J. Med. **22**:389 (Sept.) 1922; Arch. Surg. **6**:403 (Jan.) 1923.

2. Idem.: Ann. Surg. **58**:700, 1913; Arch. Surg. **6**:410 (Jan.) 1923.

3. Meyer. (Footnote 1, second reference, p. 403, Case 36.)

special anesthetist should wheel the patient, prepared by him in this way outside, ready for operation into the operating room in the same way as he would a patient under general anesthesia.

If block anesthesia plus local anesthesia is impossible or contraindicated, careful preparation of the patient with properly gaged colonic or nitrous oxid oxygen inhalation anesthesia, with as little addition of ether as possible, will reduce to a minimum the occurrence of such events as here reported.

Let surgeon and specialist remember that at this stage of the evolution of medical science preventive medicine of this type is the goal of surgical therapeutics.

SUMMARY

1. Pulmonary gangrene of any degree following aseptic operations for a noninfectious trouble done under general anesthesia, with undisturbed subsequent healing, is due to aspiration.

2. After operations required for suppurating processes the hematogenous cause, embolism, also plays a rôle in inflammatory, septic affections of the lung which disturb the immediate after-treatment.

3. The roentgenograph, which in combination with bronchoscopy is usually called on to determine the true character and localization of pulmonary affections, is of little assistance in the differential diagnosis between abscess of the lung on the one side and pneumonia due to aspiration (gangrene) with encysted perforated empyema on the other. In both the roentgenogram shows a distinct cavity with fluid level, which is not characteristic of either of them. But careful analysis of the clinical symptoms, with the roentgenogram in hand, can establish the refined diagnosis. Distinct localized dulness on percussion, absence of amphoric breathing and particularly a *rare* cough with scanty foul sputum, in spite of a large cavity with fluid level as shown by roentgen-ray examination, is the principal symptom complex. It speaks definitely for localized septic pneumonia due to aspiration (gangrene) with encysted empyema, in which the perforation and communication with the bronchial tree has occurred in its upper portion.

4. Extending the use of local with regional as well as of sacral (epidural) and colonic anesthesia, and reducing that of general inhalation anesthesia, is the principal prophylactic for avoiding these severe postoperative sequelae.

5. In existing suppurations of the lung special care is required during operations to avoid aspiration. The graded procedure seems

best for this reason in extrapleural thoracoplasty for tuberculosis with cavity formation in the upper lobe.

6. After signs of aspiration with its sequelae have developed in a hitherto healthy individual, bronchoscopy with aspiration at as early a date as possible, irrespective of high fever, and if necessary, repeated, will often mitigate or even abort a threatening serious trouble.

7. If a complicating encysted empyema has been definitely diagnosed, operation from without is the only procedure indicated.

LUNG ABSCESS COMPLICATED AND HIDDEN BY EMPYEMA

CARL EGGERS, M.D.
NEW YORK

That an abscess of the lung may perforate into the pleura has been known for a long time, but that this is a fairly frequent occurrence and that such an event augurs rather well for the patient, as far as cure of the abscess is concerned, is not so well known. I therefore feel justified in presenting this subject on the basis of ten patients who were observed during the last few years. The relation of empyema to intrapulmonary suppurative lesions is naturally an interesting one and has received considerable attention during and since the Great War. It has been reasoned by analogy with inflammatory conditions in the peritoneum that the inflammation of the pleura, in cases of empyema, is not primary but is secondary to an inflammation of the tissues underlying it. Several authors have gone so far as to state that all, or nearly all, empyema cases are due to the perforation of a subpleural abscess in the same way that acute suppurative peritonitis is usually due to the perforation of an intra-abdominal organ.

Whether this is true or not is difficult to prove because such subpleural abscesses give no clinical symptoms. We do know, however, that in lobar pneumonia of pneumococcus origin abscess formation rarely occurs, and if it does occur is due to secondary invasion with a pyogenic organism as pointed out by Hartwell [1] and by McCallum.[2] We also know that pneumococcus lobar pneumonia runs a short course, that the temperature comes down to normal quickly, and that there is complete restitution to normal. For empyema following pneumococcus lobar pneumonia we can, therefore, probably rule out the rupture of a subpleural abscess as an etiologic factor. It seems more likely that the pleura overlying the inflamed lung becomes involved in the process and that bacteria then pass through this inflamed layer directly into the pleural cavity. Similar events take place in the peritoneum and pericardium where there is by no means always gross rupture of an underlying lesion to account for inflammation of these membranes.

We do know, on the other hand, that in streptococcus and staphylococcus pneumonia abscess formation is not uncommon, and it is easy to understand how the rupture of such a subpleural abscess may lead to the development of an empyema. But even in these cases I do not believe that this is the usual course of events. A pleuritic exudate in pneumonia

1. Hartwell, J. A.: Abscess of the Lung, Ann. Surg. **72**:333 (Sept.) 1920.
2. McCallum, quoted by Hartwell (Footnote 1).

is not at all infrequent. As a matter of fact, small exudations are very common. The majority of these produce no symptoms and do not become infected. Even the more extensive exudates which can be clinically diagnosed and which may require aspiration do not always become infected. To my knowledge, from 20 to 30 per cent. of these exudates remain sterile. If infection does take place it is probably, in a great majority of cases, due to the migration of bacteria from the inflamed lung through the pleura into the exudate. Dunham [3] has shown quite conclusively that organisms in pneumonia, especially streptococci, invade the interstitial tissue of the lung and lead to pleuritis, pericarditis and even peritonitis. This assumption is further strengthened by the observation that a pleuritic exudate, especially in streptococcus infections, may remain clear for several days though filled with bacteria. Had an abscess ruptured into this exudate it would probably have become cloudy in a short time. Nevertheless, it must be conceded that small lung abscesses are probably common and that those situated peripherally may rupture into the pleura. It is impossible to tell how frequently they occur because they undergo absorption, obliterate entirely, and leave no indication that the empyema started in that way.

What evidence, then, is there that a subpleural abscess has ruptured, and is the cause of an empyema? There is, first of all, laboratory evidence that abscesses do occur in the course of some pneumonias, that they may be situated peripherally, and that such ruptured abscesses have been seen on the necropsy table. Clinically, there is little evidence that small subpleural abscesses play a rôle in the production of empyema. It is chiefly since the use of surgical solution of chlorinated soda (Dakin's solution) that any evidence at all has been produced and it is the complaint of patients that the solution produces cough and can be tasted during irrigations of the cavity. These manifestations, especially violent coughing and tasting of the solution, must indicate some communication, either with the bronchial tree or with lung parenchyma. Milder degrees of coughing may be due to superficial abrasions of the lung produced possibly by the point of an aspirating needle, by rough instrumental manipulation, from pressure of a drainage tube, or from the irritating action of surgical solution of chlorinated soda (Dakin's solution) itself.

That larger abscesses have ruptured is easy to demonstrate. One may obtain pus from the pleura similar to that which is expectorated. A bronchopleural fistula may exist, definitely proving a communication with the lung. A pyopneumothorax may have developed as the result of the rupture of an abscess with bronchial communication, and, finally, such abscesses can be demonstrated by the roentgen ray after evacuation

3. Dunham, E. K.: Infection in the Mediastinum in Fulminating Cases of Empyema, Surg., Gynec. & Obst. **35**:288 (Sept.) 1922.

of the empyema. It is with these clinical lung abscesses complicated by an empyema that this article is concerned. They may follow a pneumonia or any of the well known etiologic factors. From a study of my own cases it does not appear that the etiology plays any rôle in the position of the abscess, whether near the periphery or more centrally located, or whether it is likely to rupture or not. In only three or possibly four of the patients was there a fairly definite history of a preceding pneumonia (Cases 2, 4, 9 and 10). In three or possibly four, the onset was either sudden or gradual, but without definite antecedent pneumonia, injury, infection or operation about the mouth or throat (Cases 1, 3 and 7). In one patient, Case 8, it followed a septic abortion, and in only two patients, or 20 per cent., was it postoperative in character and therefore probably due to aspiration of septic material (Cases 5 and 6).

In this connection it is interesting to comment on the difference in percentages of etiologic factors as given by various authors. The impression has generally gained ground that lung abscesses are nearly always postoperative in character, and that they are due to aspiration of septic material, especially after tonsil operations. While due attention should be paid to this mode of development, we should nevertheless not lose sight of the fact that a great many follow pneumonia or start insidiously from an ordinary cold. In Lockwood's [4] series of fifty-three cases about 50 per cent. followed tonsillectomy or some other operation, while the other 50 per cent. followed pneumonia, influenza or were of unknown origin. Whittemore [5] states that of eight-six lung abscesses cases he has treated, 61 per cent. were immediately preceded by some operation on the upper respiratory tract, while Kernan,[6] in a recent report before the New York Society for Thoracic Surgery on seventy-nine lung abscesses treated bronchoscopically, stated that only twenty-five, or 31 per cent., had followed an operation, and, as I have stated, of the ten cases here reported only 20 per cent. were postoperative in character. Regardless of the etiology, however, all authors report the right side affected more often than the left, and my own cases bear this out, for seven were located on the right side, and only three on the left.

In determining which lung abscesses are more likely to rupture and produce empyema, one has to take their anatomic position into consideration. All abscesses must naturally be in communication with the bronchial tree, even those situated at the periphery. As long as a communication exists with only bronchioles and small bronchi there is

4. Lockwood, A. L.: Abscess of the Lung, Surg., Gynec. & Obst. **35**:461 (Oct.) 1922.

5. Whittemore, Wyman: Nontuberculous Pulmonary Abscess, Boston M. & S. J. **188**:497 (April 5) 1923.

6. Kernan, J. A.: Personal communication to the author and report before meeting of the New York Society for Thoracic Surgery, March, 1925.

evidently no adequate drainage and, as in abscesses of other parts of the body, the pus spreads in the direction of least resistance, into the surrounding lung tissue, thus increasing the size of the abscess. If the destructive process finally reaches a good sized bronchus and ruptures into it, it may be evacuated in that way. On the other hand, if it reaches the pleura before it has ruptured into a bronchus it will rupture into that. Sometimes both processes may occur simultaneously as in my Cases 2 and 3, in which it apparently perforated in both directions during a severe coughing spell. Hartwell [1] has given a beautiful description and logical explanation for the progress of these lung abscesses and also for the so-called "rupture of an empyema into a bronchus," which he believes to be a lung abscess reaching an outlet in two directions, first into the pleura and second into the bronchus.

Varied clinical and pathologic pictures may be presented by the development and course of these abscesses. The rupture may take place slowly, giving the overlying parietal pleura a chance to become adherent and forming an encapsulated empyema, as in the following case:

REPORT OF CASE

CASE 1.—T. J., a man, aged 30, a patient of Dr. Hermann Fischer, was admitted, Aug. 8, 1918, with the history that he had begun to feel sick five weeks before admission, with pain in the left chest and cough. There had been a gradual onset. He was taken to an out-of-town hospital, where he remained a bed patient. He had several thoracenteses done and was finally sent to us with a diagnosis of lung abscess. He was a sick looking man with a temperature of 102.8, pulse 116, respiration 32. He coughed a great deal, the amount of sputum varying from 200 to 400 c.c. in twenty-four hours. It had a disagreeable odor, was negative for tuberculosis, and showed no elastic fibers. Physical examination showed dulness at both apexes. There was flatness in the left chest posteriorly, with diminished vocal fremitus. There was no bronchial breathing. The roentgen ray showed a cavity in the left upper lobe, with fluid in the lower part of the chest.

August 21, an operation was done under local anesthesia. A part of the seventh and the eighth ribs was resected and a thick pleura adherent to the underlying lung was found. An intrapulmonary cavity was entered and from this another opening communicated with the empyema cavity. Both cavities were drained and the patient made an uneventful recovery. This patient had a good sized bronchial communication in addition to his pleural opening, as evidenced by the large amounts of sputum, varying from 200 to 400 c.c. in twenty-four hours, and this probably accounted for his speedy recovery after drainage of the empyema.

In other cases the perforation may come on suddenly and produce a complete acute pneumothorax with its distressing symptoms, as in the following case.

CASE 2.—P. F., a man, aged 48, a patient of Dr. Franz Torek, presumably had had pneumonia of a mild type in November, 1919. The night of Dec. 4, 1919, he was taken with a sudden sharp pain in the right side of the

chest under the scapula, which came on after a severe coughing attack. He was seen by his family physician, who found him in great distress, in shock and gasping for breath. His color was livid and he was covered with a profuse cold perspiration. He was given morphin by hypodermic injection. He was too sick for a lengthy examination, but it was reported that there were no signs in the chest except diminished breath sounds over the right side of the chest. On the following day signs of fluid were made out in the right side of the chest. The fluid accumulated rapidly so that on the following day an aspiration was

Fig. 1 (Case 3).—Ten days after drainage operation, showing collapsed lung and lung abscess shadow.

done, 1,000 c.c. of cloudy yellow fluid, which was frothy and had a foul odor, being removed. The diagnosis of pyopneumothorax was made. During the following days three more aspirations were done, each time 1,000 c.c. of pus being removed. The patient's general condition improved somewhat, though he remained acutely ill with high fever and expectorated a great deal of foul smelling pus. December 17, thirteen days after the onset, a closed drainage operation was done under local anesthesia with an intercostal stab puncture. The patient remained acutely ill for a long time. He drained profusely while

the amount of expectoration gradually diminished. Feb. 20, 1920, almost two months after the trochar drainage, a rib resection was done under local anesthesia for better drainage of the thorax. Recovery was slow. Drainage persisted until about April 15, 1920, when the tubes were removed. It was about a year before the wound had entirely healed. During the early part of his convalescence he was given morphin liberally; this was later discontinued without any trouble. Whisky was given at all times during convalescence. The patient eventually made a complete recovery.

Fig. 2 (Case 3).—Two months after operation, showing cavity filled with bismuth; lung abscess shadow still present.

In this case the condition was recognized early and though the patient expectorated pus the thorax was drained as soon as he had overcome the most acute symptoms. Previous to the rupture of the abscess, he had not expectorated pus and the sudden rupture was probably due to the tension within the abscess, which was increased by coughing. The violence of the rupture produced an opening into the pleura sufficient for adequate drainage so that no secondary operation on the abscess itself was required. The rib resection done two months later was necessary for proper drainage of the empyema. The long convalescence in

this case was due partly to the persistence of a bronchopleural fistula and partly to the collapse of the lung, the result of this fistula.

In Case 3, also, the rupture into the pleura was sudden, and at operation a collapsed lung was found which necessitated long drainage and was responsible for a protracted convalescence. She probably had an abscess situated near the hilum which ruptured into the mediastinum and produced an empyema necessitatis and, either at the same time or later, a posterior pyopneumothorax.

Fig. 3 (Case 4).—Four days after onset of pneumonia.

CASE 3.—M. J., a woman, aged 30, was admitted, Sept. 13, 1923, more than three months after the onset of her disease, complaining that she had been taken suddenly ill June 6, 1923, with pain under the sternum. The following day she had a temperature of 104; her physician diagnosed the condition as pleurisy. The pain under the sternum and high fever continued. About one week later she began to cough but did not expectorate. Two weeks after onset, a small soft swelling was discovered in the anterior right chest wall. An exploratory puncture revealed thick pus with an offensive odor. An incision was made over this swelling under local anesthesia and fluid was evacuated, but no pus such as had been obtained by aspiration. About five or six days later the cough became worse and the patient began to expectorate foul smelling, greenish pus; at the same time the wound began to discharge similar pus in large quantities. She had been in bed since the onset of illness and the cough and expectoration had continued, sometimes more, then again less. Three weeks before admission another incision

had been made in the right anterior chest over the costal cartilages, allowing better drainage. On admission she coughed almost incessantly, this preventing sleep. She expectorated large quantities of pus of a most offensive odor, complained of nausea and vomited frequently. She had always been well up to the onset of the present trouble. She had no infection of the mouth and had had no dental work done just before the onset. She had lost about 15 pounds (6.8 kg.) in weight and was an anemic, sick looking girl, who coughed and expectorated constantly. The temperature was 100.4, pulse 140, respiration 38. The white blood cells totaled 17,200, and the polymorphonuclear 77 per cent.

Fig. 4 (Case 4).—Ten days after onset of pneumonia.

Examination showed flattening of the right side of the chest with restricted respiration. There was a 2 inch (5 cm.) horizontal scar over the cartilage of the fourth rib, exuding pus from a narrow sinus. There was another smaller scar more external, just beneath the nipple, with a sinus tract running through the breast tissue to the chest wall. Further examination showed a pyopneumothorax involving the entire right chest posteriorly, with absent fremitus and voice below. There was no cardiac displacement. The provisional diagnosis was empyema necessitatis anteriorly with an underlying lung abscess and

secondary posterior pyopneumothorax. An exploratory puncture in the eighth intercostal space posteriorly showed thick, dirty green, foul smelling pus similar in character to that which she expectorated. A smear of this pus showed short chain streptococci which did not grow on any culture medium. September 15, an operation was done under local anesthesia (0.5 per cent procain), a portion of the eighth and the ninth ribs was resected and a rigid, thick walled cavity extending from the diaphragm to the apex was entered. The cavity was partly filled with thick, foul smelling pus. The lung had collapsed, was covered with

Fig. 5 (Case 4).—Fifteen days after onset of pneumonia.

greenish exudate, and did not expand even on straining (Figs. 1 and 2). No bronchial communication could be made out. Whether the expectorated pus came from the empyema cavity or from an intrapulmonary focus that had become closed off toward the pleura could not be determined. The parietal pleura was one-half inch (1.27 cm.) thick. A section was taken and sent to the laboratory. The patient reacted well. The cough and expectoration ceased at once, but the empyema cavity continued to drain profusely. While it was being irrigated six days after operation, violent coughing was induced; this indicated a bronchial

communication, which was definitely made out two days later. The patient was allowed out of bed one week after operation.

Drainage from the anterior sinuses gradually increased in amount and, October 3, an operation was done which exposed the fourth and fifth costal cartilages, which were in a state of suppuration. Both cartilages were completely resected. No connection with the lung could be made out. Except for minor disturbances, both the anterior and the posterior wounds progressed satisfactorily and the patient was discharged cured, July 23, 1924, thirteen months after the onset of the disease. She has gained much in weight and is entirely well.

Fig. 6 (Case 4).—Four days after operation.

Occasionally large abscesses form within the lung which contain so much pus that they are mistaken for empyema. Such abscesses probably start as peripheral abscesses. They have no, or only the minutest, bronchial communication; consequently these patients do not expectorate pus or at any rate not sufficient to aid in the diagnosis. In case the

abscess has not perforated into the pleura one may favor its rupture by introducing a drainage tube into the thorax, as illustrated in the following case.

CASE 4.—J. S., a boy aged 11 years, a patient of Dr. N. K. Benton, was admitted, Sept. 23, 1924, three days after exposure while swimming. There was no evidence of his having aspirated water. He developed pain in the right side of the chest, cough and fever. On admission he looked extremely sick, was cyanotic, had a temperature of 104.4, pulse 120, and respiration 44. There was marked

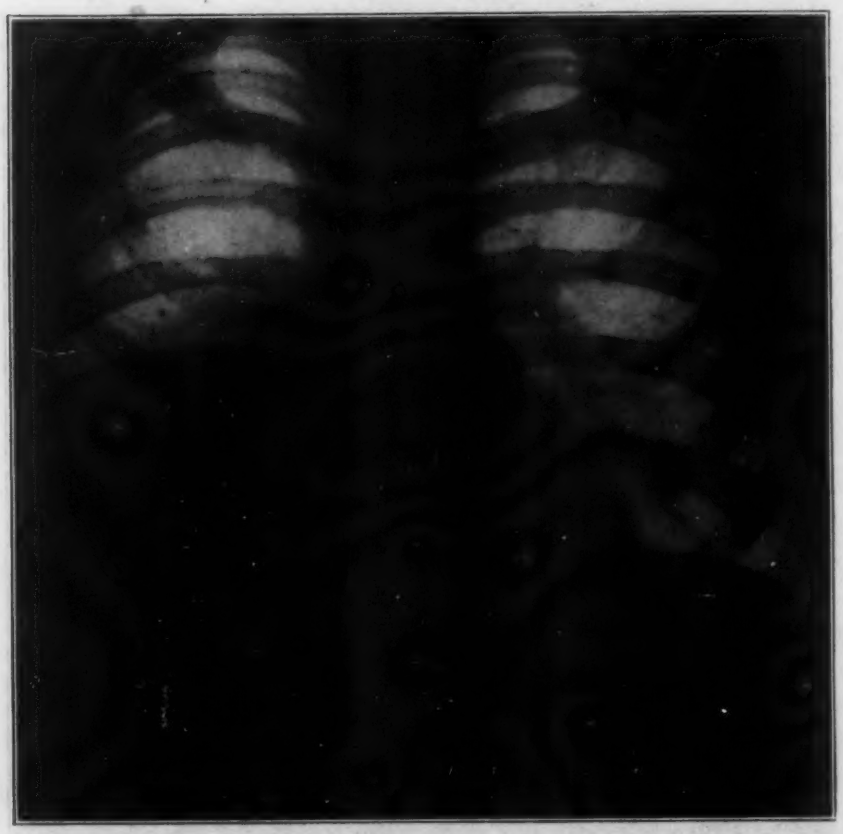

Fig. 7 (Case 4).—Twenty-six days after operation.

dyspnea. The white blood cells totalled 24,400; the polymorphonuclears, 84 per cent.

Up to the time of onset he had been perfectly well. He had never had pneumonia before. There was tuberculosis in the family history. He was a well developed boy, showing moderate cyanosis. He had herpes of the upper and the lower lips. He looked acutely ill and was breathing rapidly. There was dulness over the right side of the lower part of the chest posteriorly with diminished tactile and vocal fremitus.

The diagnosis of right lower lobar pneumonia was made. The Pirquet reaction was negative and all sputum examinations for tuberculosis were negative.

October 11, an exploratory puncture showed thick pus which was negative on culture but showed streptococci in the smear. On the same day the patient was operated on under local anesthesia with the diagnosis of empyema. Three inches (7.6 cm.) of the ninth rib were resected. A puncture after the rib resection resulted in the withdrawal of thick pus. The needle was left in place and an incision made alongside it. As soon as the pleura was opened, there was an inrush of air with collapse of the lung and the needle became dislodged. The pleural cavity was found to be empty and search failed to reveal any pus. The pleura

Fig. 8 (Case 4).—Two months after operation.

was in an irritated state and the patient was in great distress. General ether anesthesia was therefore given and the lung was inflated. Two needle punctures were seen on the outer surface of the lower lobe, but additional punctures failed to strike the abscess. A large tube was therefore inserted into the pleural cavity for the purpose of drainage because it was feared that the pleura had been infected; it was hoped that the lung abscess would rupture into it. The muscles and skin were closed around the tube and closed drainage was then instituted. No acute pneumothorax or pyopneumothorax resulted. The drainage

through the tube at first was slight but after five days, during a severe coughing spell, the patient coughed up two basinfuls of blood tinged pus; on the following day he began to drain large amounts of pus of the same character. This discharge increased daily for awhile and then gradually diminished. About a month after operation a bronchial communication was definitely made out. Convalescence was uneventful and Feb. 15, 1925, the patient was discharged, cured. The long convalescence of five months was due to the persistence of the bronchial fistula.

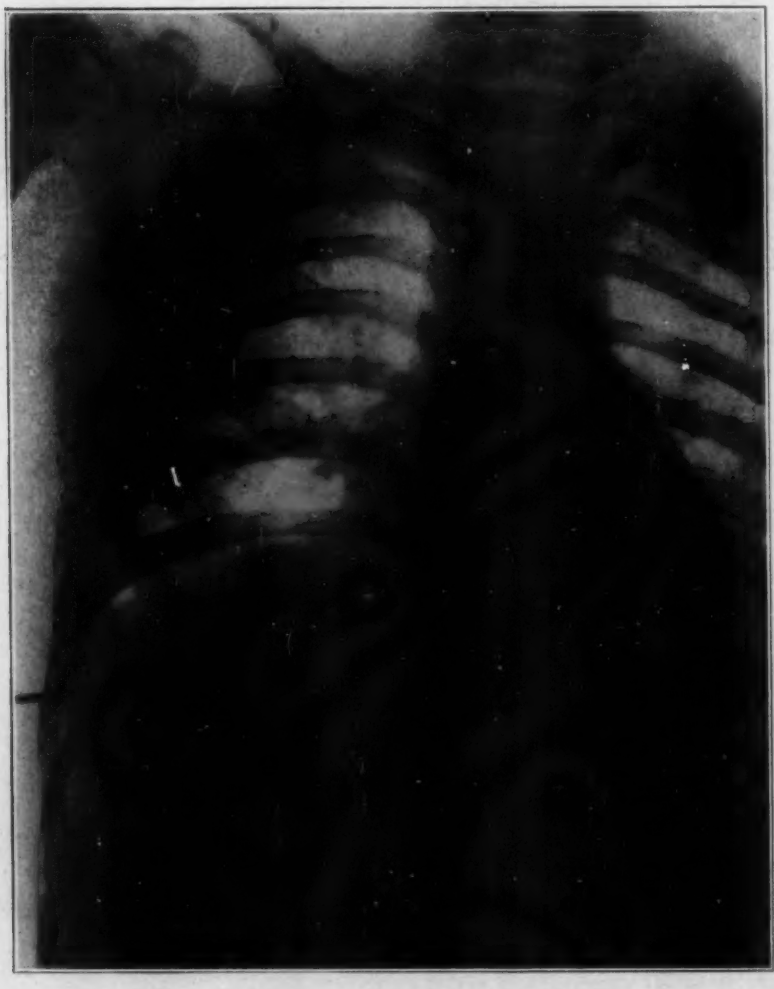

Fig. 9 (Case 4).—Four months after operation, showing probe engaged in bronchial fistula.

In this case the etiologic factor was not definitely determined. The boy may have aspirated water while swimming. On the other hand, the condition may have been a straight pneumonia of streptococcus origin, with secondary lung abscess formation (Figs. 3 to 9). This case shows that one may have a lung abscess with only streptococci and no

mixed infection and without any odor. The usual opinion is that lung abscesses contain many varieties of organism and that the pus has a foul odor.

The simplest course takes place in those cases in which there is early rupture into the pleura and in which the opening is sufficiently large to drain the abscess properly. Spontaneous cure will result from simply draining the empyema. The following case illustrates such a condition even though the abscess had been present seven months. The patient was discharged after seven weeks, practically cured.

Fig. 10 (Case 5).—Extensive empyema on admission.

CASE 5.—H. C., a boy, aged 17 years, a patient of Dr. Hermann Fischer, was admitted, Sept. 21, 1922, complaining of pain in the right chest, cough and expectoration. He had had his tonsils removed in April, 1922, seven months before, under general anesthesia. Three days later he had begun to cough and had been coughing since. For two weeks before admission he had had bloody expectoration. He had lost 16 pounds (7.3 kg.) in weight; recently, while in the country he had regained 10 pounds (4.5 kg.). After his tonsillectomy, he had chills followed by fever every evening between 5 and 6 p. m.; this lasted until two months before admission. He also had night sweats during this period. His

cough has always been productive, with occasional blood tinged sputum and accompanied by pain in the right side of the chest anteriorly. Previous to his operation he had been a healthy boy. There was no tuberculosis in the family history. On admission the temperature was 103.6, pulse 144, respiration 36. The white blood cells totalled 23,000; the polymorphonuclears, 92 per cent. The sputum was negative for tuberculosis, but showed elastic fibers and pus cells. Exploratory puncture showed thick pus containing gram-negative bacilli, gram-positive diplococci, and streptococci. There were no tubercle bacilli present. The

Fig. 11 (Case 5).—Fifteen days after operation, showing lung abscesses in upper lobe.

boy looked extremely sick, had marked dyspnea, a severe cough and raised sputum. Deep breathing caused pain in the right side of the chest.

Examination showed an area of tenderness over the right side of the lower part of the chest anteriorly, extending from the nipple line downward to the inferior costal margin and laterally from the nipple line to the anterior axillary line. Examination of the chest anteriorly showed flatness with bronchial breathing from the apex downward, diminishing over the lower half, with absent vocal fremitus and diminished breath sounds. Posteriorly there was dulness from the right apex downward to the angle of the scapula. Below this there was

flatness. There was bronchial breathing over the upper part of the lung and absent breathing below with absent fremitus.

From the history the diagnosis seemed to be one of lung abscess following tonsillectomy. From the physical examination the diagnosis of empyema was made. The latter diagnosis was verified by roentgen ray. October 5, the patient was operated on; a portion of the tenth rib was resected and the pleura was opened, with the discharge of a large amount of most offensive pus. The boy rapidly improved. The sputum diminished gradually from 150 c.c. in twenty-four

Fig. 12 (Case 5).—Two months after operation, showing lung almost healed and lung abscess cleared.

hours to none at all at the end of five weeks. After evacuation of the pus the roentgen ray showed an intrapulmonary focus which was no doubt the primary lesion (Figs. 10 to 13). The patient was discharged November 29, two months after admission, with a small sinus discharging serous fluid.

Many such cases with a peripheral abscess and no bronchial communication may never be recognized as lung abscess. It is important in all these cases to have free thoracic drainage and it must also be possible

for the lung abscess to drain freely into the pleura. In case there is any obstruction there will be damming back of pus with constant reinfection and a long convalescence. This is illustrated by the following case:

CASE 6.—C. K., a man, aged 54, was operated on under ether anesthesia, Jan. 6, 1922, for a perforated duodenal ulcer. He made an uneventful recovery except for an obstinate cough which he developed two weeks after operation and which was accompanied by pain in the right side of the lower part of the chest and a temperature as high as 101.4. He attributed the condition to an old recurrent

Fig. 13 (Case 5).—One and a half years after operation, showing lung completely healed; no evidence of lung abscess remaining.

bronchitis, and not much attention was paid to it. Physical examination of the chest was negative and a roentgenogram was not taken. At the time of discharge he had an evening temperature of 100. His cough did not quite clear up, though he was not acutely ill. He lost weight gradually. At times the sputum had a disagreeable odor. In July, 1922, about six months after operation, he became acutely ill, with fever, chills, pain in the chest, excessive cough, and an increase in the amount of sputum. The latter was very disagreeable and had a sour taste. He was taken to a hospital in a serious condition, and several operations

for drainage of an empyema were done in the course of the next few months. The general condition gradually improved, but in spite of that he had one flare-up after another and was entirely incapacitated. He came under my care about one year after the first empyema operation. At that time he was expectorating blood clots and foul smelling pus with a sour taste. His cough was most severe at night. He had no pain in the chest, just a sore feeling. His temperature was

Fig. 14 (Case 6).—Old lung abscess with imperfect drainage.

100.6, pulse 108. There was extensive scarring of the right side of the chest owing to the several drainage operations, with moderate flattening of the chest and restricted respiration. In the posterior aspect of the right side of the chest, in the middle of a long broad scar extending obliquely downward and forward over the lower ribs, there was a narrow fistula exuding thick pus. Owing to the contracted opening a tube could not be inserted but a probe was entered in an upward direction for 4 inches (10.1 cm.).

Roentgen-ray examination showed resection of part of the tenth and the ninth ribs with an area of pulmonary density at a higher level (Fig. 14). Aug. 2, 1923, an operation was done under local anesthesia. A part of the eighth and the formerly resected ninth and tenth ribs was removed. A thick walled cavity was laid well open; it was found to be located in the lung and to hold from about

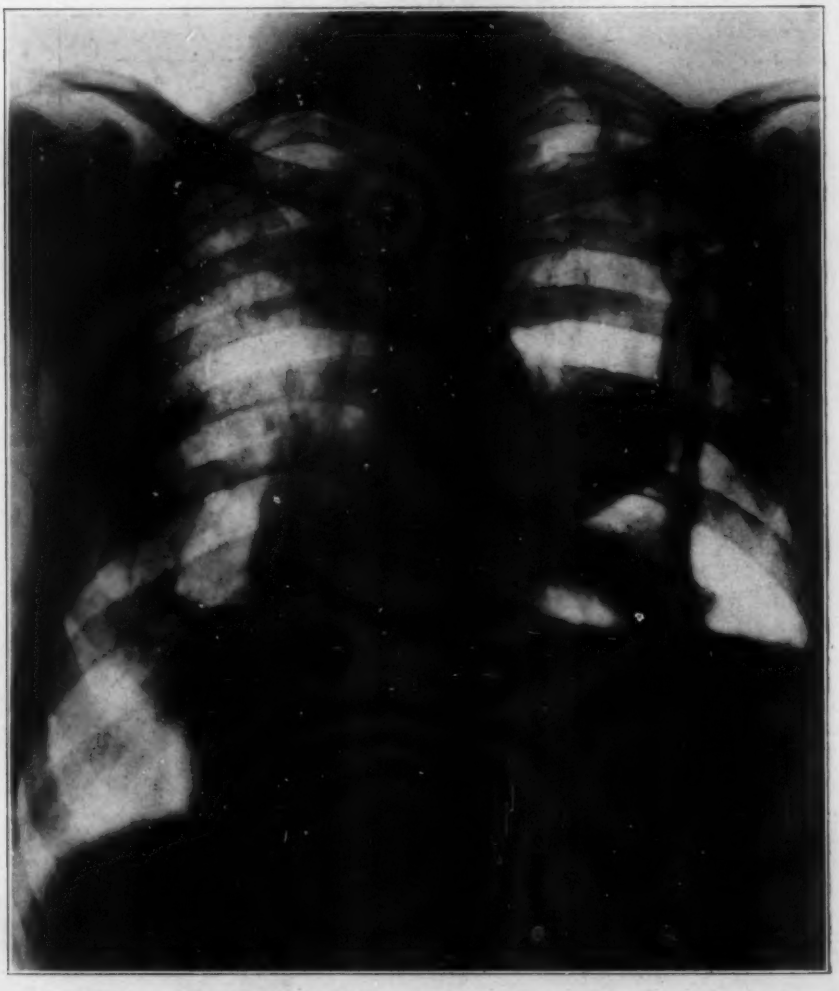

Fig. 15 (Case 7).—Appearance after first aspiration of 1,450 c.c. of pus, showing two fluid levels, one in the empyema cavity, the other in what was later diagnosed as a lung abscess.

3 to 4 ounces (89 to 118.4 c.c.). The lung margins were hard and sclerosed. A small piece was excised for diagnosis. One bronchial fistula was noted in the depth of the cavity. There was no discharge on straining. The lung was mobilized and a tampon was then inserted into the cavity. Cough and expectoration of blood and pus ceased at once.

The patient was discharged, September 16, six weeks after operation, with a bronchial fistula still present. He was completely healed October 30, three months after operation, and fifteen months after his original empyema drainage. He has gained in weight and strength and has remained healed. The pathologic examination of the excised lung tissue showed chronic pleuritis and pulmonary

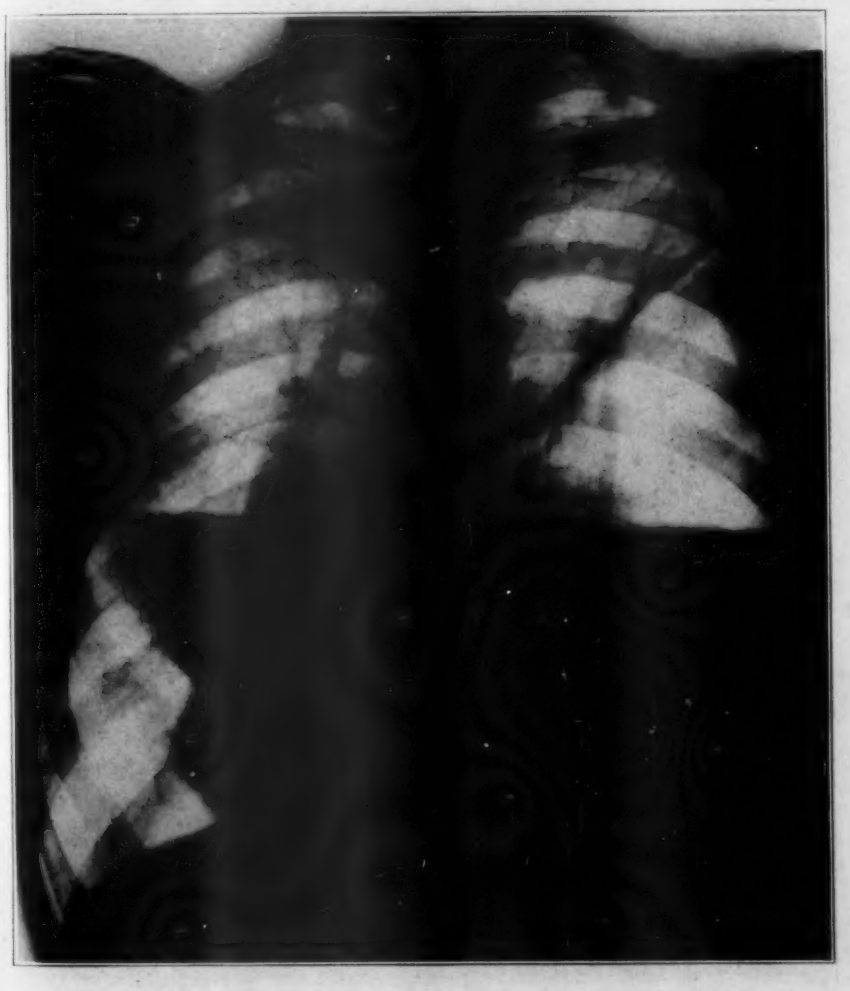

Fig. 16 (Case 7).—Fluid level when patient was in erect position.

fibrosis. The vessels in the lung showed marked sclerosis. The septums of the lung were much thickened and the alveolar walls were collapsed. There was no evidence of tuberculosis.

A review of this case would indicate that the patient developed a lung abscess after an abdominal operation, probably because of aspiration, and that it later perforated into the pleural cavity. The various empyema operations relieved him greatly, but on account of the small size of the

perforation there was not sufficient drainage, and whenever the cavity filled up he coughed and expectorated blood and pus. Proper drainage and mobilization of the lung brought immediate relief.

CASE 7.—A. K., a man, aged 40, presented an interesting case because he had a large lung abscess that did not communicate with the bronchial tree except in the very beginning, when he had hemoptysis and a slightly productive cough.

Fig. 17 (Case 7).—Fluid level when patient was in erect position with left inclination.

The abscess perforated into the pleura and he developed a most extensive pyopneumothorax, which eventually extended to the opposite side and gave the impression of being a bilateral empyema.

He was admitted, Dec. 19, 1922, complaining of weakness, dyspnea, fever and cough. For more than two years he had complained of slight dyspnea and productive cough. On one occasion, about two years before, while lifting a heavy weigh, he expectorated about a cupful of blood. He did not consult a physician,

but kept right on working. He dated his trouble from this hemoptysis, stating that he had not been quite well after that, and that he could feel and hear splashing sounds in the left side of the chest whenever he bent over at his work as a boiler fireman. He did not remember whether he had fever. On the advice of his employer, who noticed that he was short of breath, and who suggested that he might have tuberculosis, he went to California and remained in the West

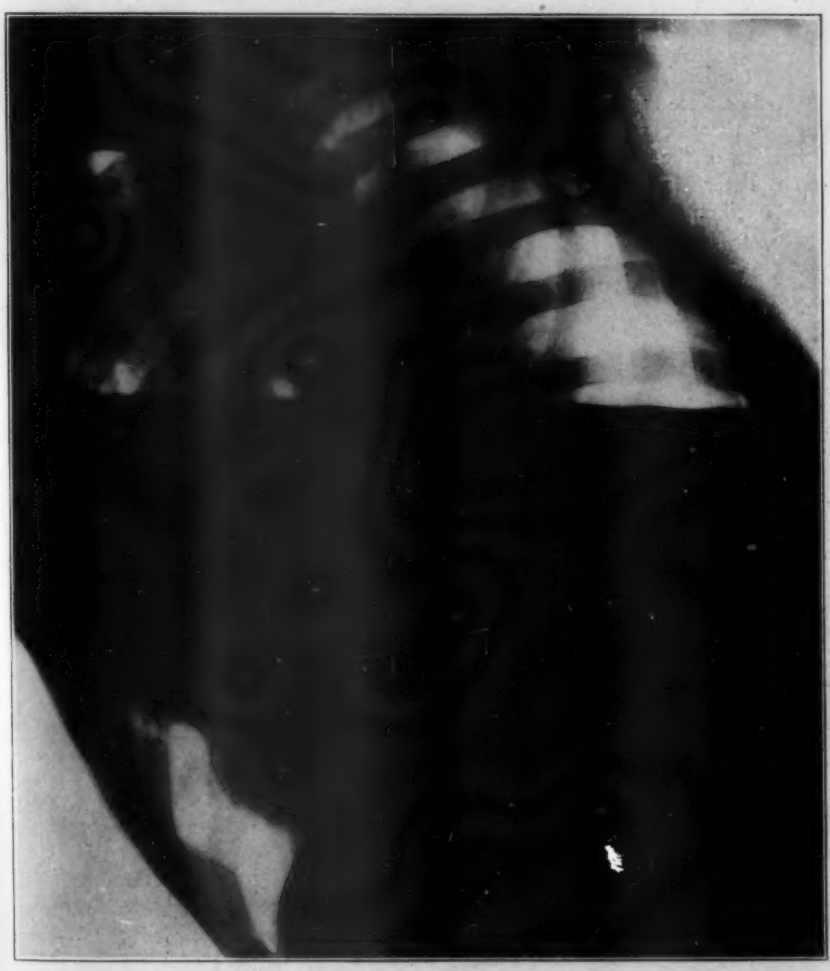

Fig. 18 (Case 7).—Fluid level when patient was in erect position with right inclination.

for almost two years. Hemoptysis did not recur but dyspnea and splashing sounds in the chest continued. In June, 1922, he returned to New York and found employment requiring a great deal of exposure. He gradually lost weight.

A week before admission he was taken sick with weakness, loss of appetite, chilly sensations and cough. He gradually became worse and was sent to the hospital, service of Dr. Otto Hensel. He looked extremely sick; his temperature was 103, pulse 120, and respiration 28. The systolic blood pressure was 110;

the diastolic 70. The physical signs were confusing, but a diagnosis of pyopneumothorax was made and 1,450 c.c. of pus was aspirated from the left side of the chest. The smear was negative for tuberculosis, and the culture showed long chain streptococcus. Blood examination showed 90 per cent. hemoglobin; no abnormal red cells. The white blood cells totaled 15,200; polymorphonuclears, 93 per cent. A blood culture was negative, and the sputum was negative for tuberculosis. The Wassermann reaction was negative.

A roentgenogram was taken after the first aspiration (Fig. 15), but it was difficult to interpret, on account of two fluid levels and a shadow extending to the right side. The fluid rapidly reaccumulated and a few days later roentgen-ray studies were repeated, with the interesting findings shown in Figures 16 to 20. Various theories were advanced to explain this fluid level shifting as one on both sides of the thoracic cavity. By careful mapping of physical signs, chiefly by Dr. Peter Maue, house physician, it was finally determined that the condition had started on the left side and had gradually dissected over anteriorly to the right

Fig. 19 (Case 7).—Fluid level when patient was lying on right side.

side, without involving the right pleural cavity. When it is considered that the patient had a pyopneumothorax for about two years, and that he continued at hard physical work all this time, it is possible to conceive of such a process. The origin of the pyopneumothorax remained in doubt, though we strongly considered tuberculosis as the underlying cause, especially in view of the history.

The patient continued in a critical condition, the temperature ranging from 103 to 104 for several weeks. We therefore did not feel justied in operating and simply aspirated pus in order to relieve the respiration and circulation: On the fifth day after admission, 1,725 c.c. was withdrawn; on the ninth day, 1,175 c.c., and on the fourteenth day, 1,000 c.c. On the nineteenth day after admission, Jan. 6, 1923, he was operated on under local anesthesia, a part of the tenth rib being resected posteriorly; 1,800 c.c. of pus was evacuated at once and closed drainage was then established. During the first twenty-four hours he drained 3,000 c.c. and during the next twenty-four hours, 3,300 c.c. After that the amounts gradually diminished. Eleven days after institution of closed drainage the tube was removed and open drainage was established. Through this opening

the cavity was carefully examined by means of a cystoscope, but not much was learned from this except that it extended through the anterior mediastinum to the right side. The temperature gradually came down to 101-102, with occasional high rises. February 18, six weeks after operation, the cavity was measured and still held 1,500 c.c. A roentgenogram taken March 22 with the patient on the affected side showed three fluid levels, one in the cavity, one in a supposed sacculated cavity and a third in the stomach (Fig. 21). On the following day the cavity was injected with bismuth in oil which showed definitely that the extension to the right side had been entirely obliterated and that we were now dealing with a left sided empyema only (Figs. 22 and 23).

For the purpose of getting drainage for the sacculated cavity supposed to be situated anteriorly, the patient was operated on, March 26, 1923, the fifth rib being resected anteriorly; this gave entrance to a rigid cavity extending upward anteriorly as far as the apex. The general condition improved somewhat, though

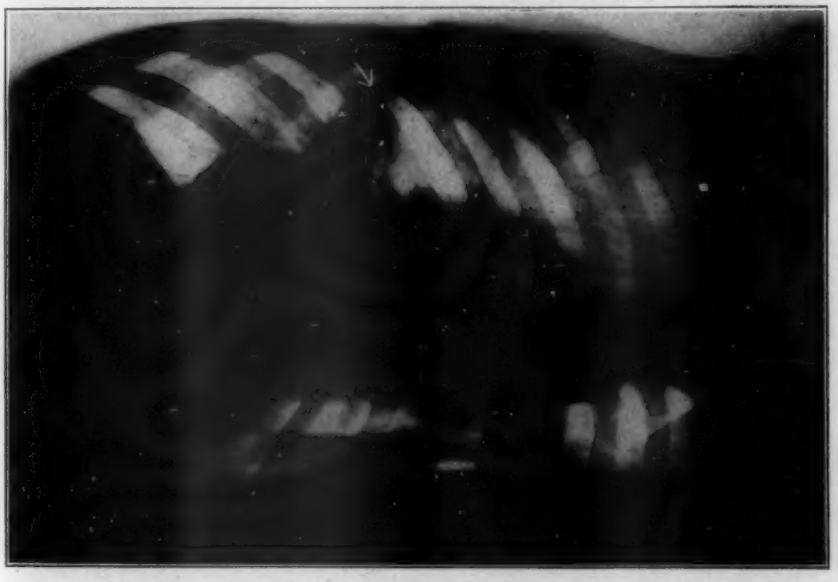

Fig. 20 (Case 7).—Fluid level when patient was lying on left side.

he was troubled much with multiple arthritis. About four months after the first operation the cavity had considerably diminished, holding only 500 c.c.; but the extension anteriorly to the apex did not seem to diminish at all, and a fluid level in a sacculated cavity was still present (Fig. 24). The patient began to have repeated, severe hemorrhages from this cavity, the origin of which we could not determine.

For the purpose of accessibility and also in order to help obliterate the cavity, another operation was done in September, 1923, the fourth, third and second ribs being resected and the soft parts allowed to retract. The hemorrhages ceased for a while but then returned, and were at times difficult to control. We were now dealing with a shallow anterior cavity the floor of which was formed by lung covered with thickened visceral pleura (Fig. 25). The hemorrhages would come unexpectedly even during the night, and would almost exsanguinate the patient. Pressure did not control them. At times they stopped spontaneously;

at other times they were controlled by means of a Paquelin cautery or by deep hemostatic sutures. During all this time the patient's resistance was so low that a radical operation for the closure of the large defect could not be considered. Several minor operations for obliteration of recesses or for the removal of necrotic cartillage were done, however. In the meantime efforts were made to determine the underlying condition. All sputum examinations were negative for tuberculosis and tissue excised at the various operations was reported negative for tuberculosis.

Finally, his general condition seemed to warrant more extensive operating and, July 21, 1924, he was anesthetized for the purpose of doing a decortication on the exposed lung and then uniting the skin over it. While doing this we accidentally entered an enormous lung abscess cavity at a place where the outer wall was quite thin. It was about the size of a fist, had a smooth lining, and

Fig. 21 (Case 7).—Three fluid levels when patient was lying on affected (left) side.

contained some pus without odor. Several strands of tissue passed through the cavity. No bronchi were visible. The greater part of the thin outer wall was removed; the bleeding was controlled by hemostatic sutures, and the cavity was then packed with gauze. From that day hemorrhages ceased and the patient's general condition improved. In the course of several months the abscess cavity became entirely obliterated and the patient was sent to a convalescent home. After his return the defect was closed as shown in Figure 26. A roentgenogram taken May 1, 1925, shows the lung fairly well expanded with no indication of an old lung abscess (Fig. 27).

In most cases there is some bronchial communication and the patient expectorates pus. As a result the tension in the abscess is not great and consequently the pleural perforation is not large. There is a

gradual leakage with the production of an encapsulated empyema. Nature's effort is directed at emptying the abscess cavity. If, therefore, the bronchial communication is large, the opening into the pleura may be corresponding small. If, on the other hand, the rupture

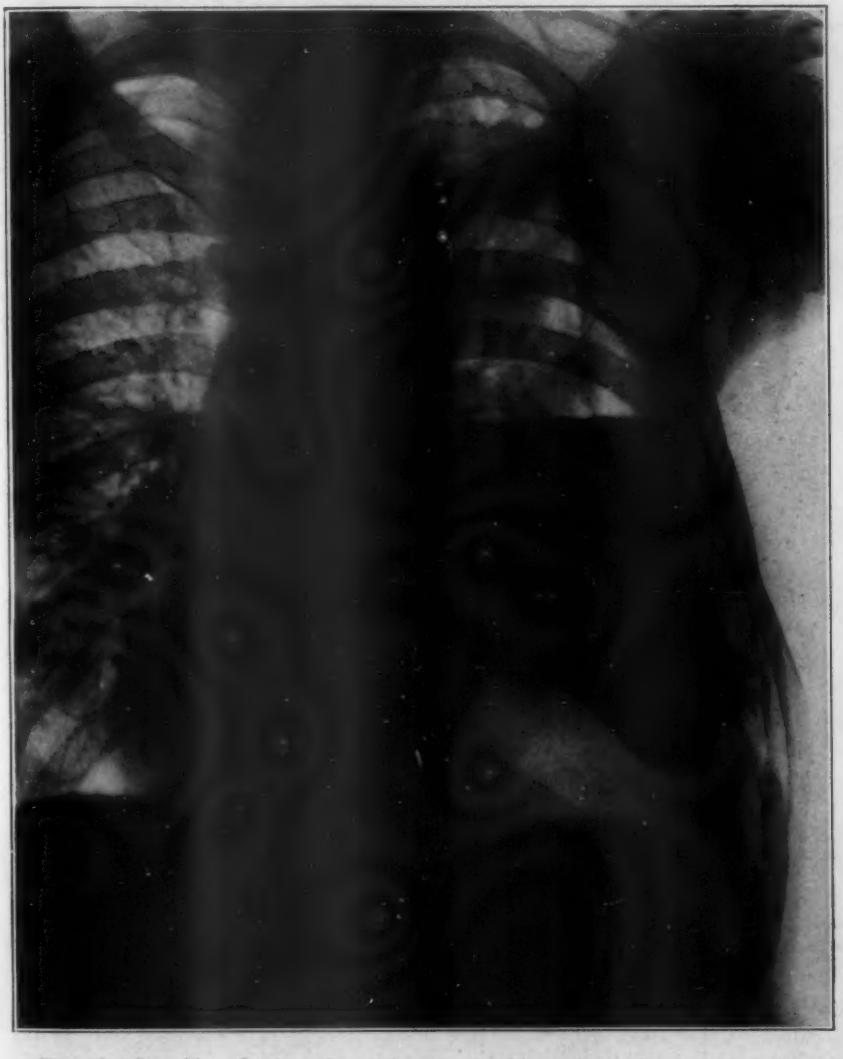

Fig. 22 (Case 7).—Cavity when injected with bismuth in oil, showing obliteration of extension to right side.

into the pleura is large, allowing free exit of pus in that direction, there will be little or no pus expectorated. To the latter group belong chiefly the peripheral abscesses. It is well illustrated by the following case.

CASE 8.—M. W., a woman, aged 32, was admitted, Oct. 31, 1923, complaining of pain and swelling of the right arm and shoulder of eight days' duration. The pain was so severe that she was unable to sleep.

She had had a miscarriage three weeks before. Two weeks before she had a severe chill followed by fever, which in turn was followed by pain in the right side of the chest, dyspnea and bloody expectoration. Eight days before swelling of the right arm and shoulder developed. Examination showed an extremely sick woman with a temperature of 103.2, pulse 150, and respiration 40. The right arm and shoulder were enormously swollen, red, hard and tender. Fluctuation was present over the entire upper arm, and shoulder motion was restricted. Multiple incisions were made, an enormous amount of pus being evacuated; on culture this showed *Staphylococcus aureus.*

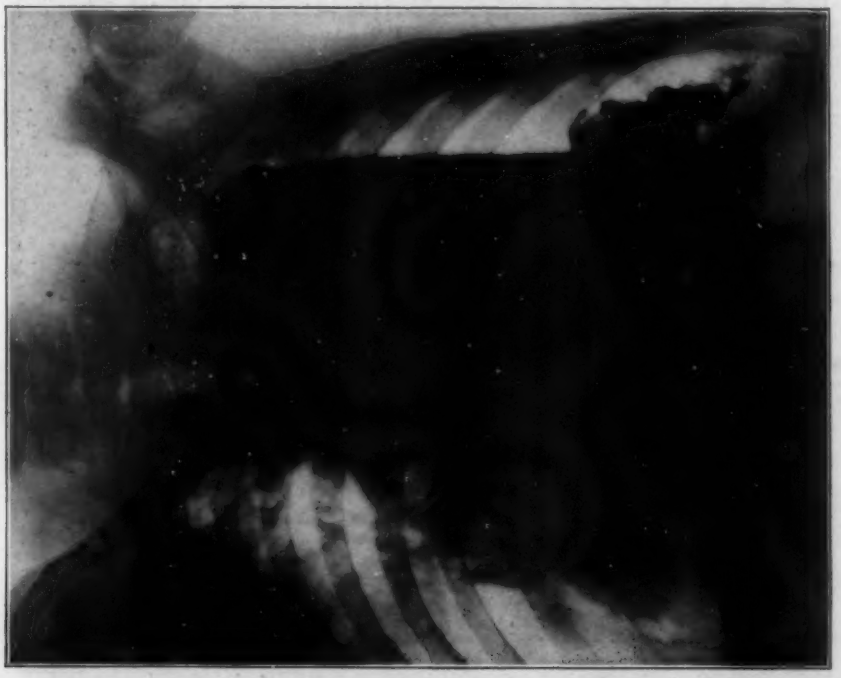

Fig. 23 (Case 7).—Cavity when injected with bismuth in oil, showing obliteration of extension to right side.

The patient was extremely septic, irrational most of the time, and her condition was poor. A blood culture was sterile and the Wassermann reaction was negative. Two weeks after operation it was noticed that the right side of the chest was immobile. The percussion note was flat posteriorly and in the axilla, with absent fremitus and voice sounds. Anteriorly, breathing was harsh and accentuated. An exploratory puncture in the posterior right chest showed thick, foul smelling pus which on culture grew *Staphylococcus aureus.* On the following day a part of the eighth rib was resected under local anesthesia. The temperature at this time was 102.6, respiration 32, pulse 140. The empyema cavity was filled with putrid pus of which about 1,000 c.c. was removed. While evacuating it a large fragment of gangrenous lung, representing from one fourth to one-third

of a lobe, was extruded, exposing a red bleeding surface on the lower lobe of the lung (Figs. 28-29). Several open bronchi were noted. An iodoform tampon was packed against this bleeding surface and the thorax was then partly closed. The operation did not influence the temperature, for it did not come down until after six weeks. The patient was treated as though she had a regular empyema, and the cavity was gradually obliterated. The small bronchi closed spontaneously and did not prolong the convalescence.

Fig. 24 (Case 7).—Persistent fluid level in what was supposed to be sacculated part of empyema cavity, but later proved to be lung abscess.

The patient was discharged, Jan. 16, 1924, about two and one-half months after admission, in a much improved condition and with the thoracic wound healed. Examination of the gangrenous lung showed necrosis, although the architecture of the tissue and the outline of many of the cells was still preserved. Scattered through the lung were collections of coal dust pigment and here and there clumps of bacteria (cocci). The patient had probably had a septic infarct of the lung from the miscarriage and later desquamation of the entire affected

portion of the lung, with secondary development of an empyema. As long as the pus was under pressure in the thorax it kept the necrotic fragment against the lung, but as soon as the pressure was released, it separated, exposing the bleeding surface.

In the cases of long standing, with pus draining freely by way of the bronchi and with a contracted drainage opening into the pleura, this may later become shut off entirely, so that the empyema heals,

Fig. 25 (Case 7).—Shallow cavity in anterior from surface of which severe hemorrhages occurred.

but repeated reaccumulations of pus will take place in the abscess and a chronic cavity will result. Owing to the previous long continued drainage the virulence of the bacteria has gradually diminished so that no acute symptoms are present except from time to time when there is a lighting up of the old infection or when a secondary infection supervenes. Such patients are chronic invalids. It is surprising how

long they may continue under treatment before the true underlying condition is recognized. It is probably the enormous size of some of these abscesses which allows them to be mistaken for empyema.

In Case 9 the patient was diseased twenty years before the lesion was recognized and treated in such a way as to make him reasonably happy and able to live among other people.

Fig. 26 (Case 7).—Final result, showing opening completely healed except for small superficial granulating surface.

Case 9.—H. W., a man, aged 29, a patient of Dr. Franz Torek, was admitted Jan. 3, 1923, complaining of cough and expectoration of huge quantities of foul smelling sputum. He was admitted for bronchoscopy, having been under treatment in the bronchoscopic department for five months, when it was discovered that he apparently had an empyema; he was therefore transferred to the surgical service.

At 9 years of age, twenty years before admission, he had an attack of bronchitis or bronchopneumonia which lasted a long time. Since that attack he had never been well. For the first five years he expectorated thin watery material that was nonodorous on coughing. He often coughed up a pint (473.11 c.c.) of this in the course of the day. When he was between 15 and 16 he went to a New York hospital to have his tonsils removed, but the operation was

Fig. 27 (Case 7).—Final result, showing lung well expanded and clear; the prominent nonresected ribs are the eighth and the ninth.

refused on account of cardiac weakness. He then went to another hospital where the tonsils were removed under local anesthesia, with the patient in a sitting position. Two months later a diagnosis of empyema was made, and he was operated on under ether. A rib resection was done and he drained for four months. After he had been healed for awhile and following a severe cold, he first began to cough up foul smelling pus. This was about twelve years before

admission. He was sent to the country and improved generally, though the cough and raising of sputum persisted. About nine years before admission a diagnosis of lung abscess was made. He was again operated on under general anesthesia and the abscess was drained. The pus was foul smelling at that time. He improved somewhat but continued to expectorate half a cup of foul pus a day for many months. For the last five months he had been on bronchoscopic treatment, having received twenty treatments in all. He had occasional

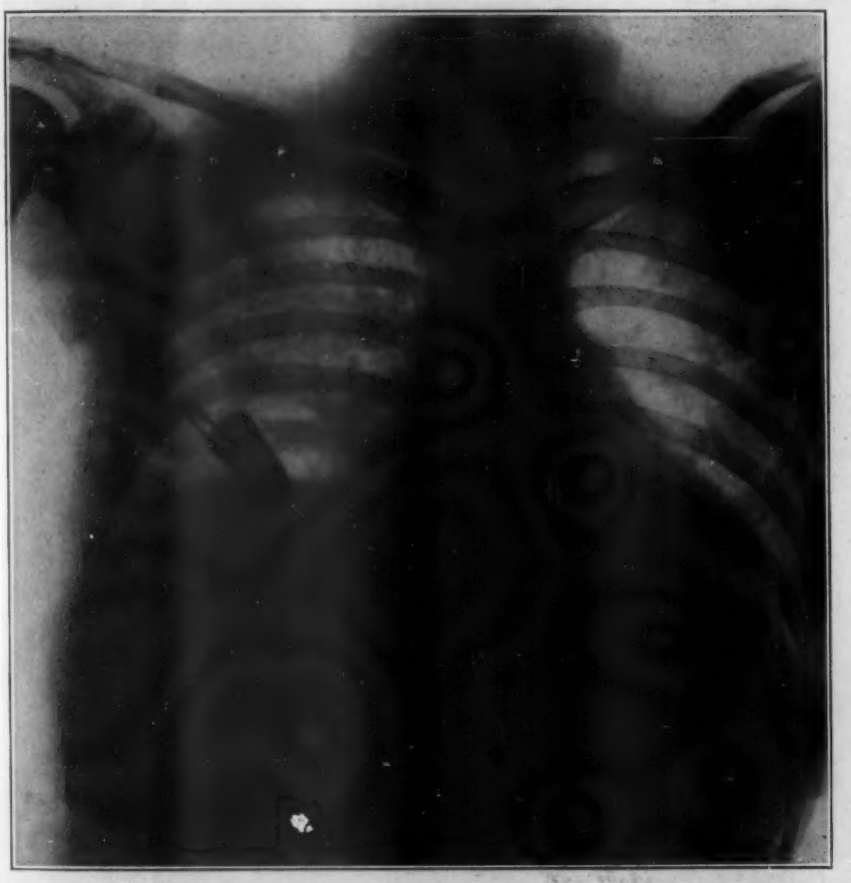

Fig. 28 (Case 8).—Appearance a few days after evacuation of empyema and gangrenous portion of lung.

night sweats. On admission he was not acutely ill and was in fairly good condition. His temperature was 99.8, pulse 90, respiration 20. He had the characteristic signs of pulmonary suppuration with clubbing of the fingers and a most offensive breath. When turned on the normal side, there was an immediate profuse expectoration of about a cupful of foul sputum. Emptying the cavity gave considerable relief. The left side of the chest was rather fixed. He had flatness at the left base with signs of a cavity and the fluid gave a splashing sound when he was shaken (Fig. 30).

An operation was performed, January 13. At the left posterior aspect and in the axillary region there was a scar of a tongue shaped flap with the anterior pedicle corresponding to the ninth and the tenth ribs. To avoid disturbing nutrition of the flap the new incision was made in the lower limb of the old incision, slightly longer than the old one. The ninth and the tenth ribs were exposed at the site of the old operation, but the exposure extended further backward and forward. The ninth rib had partly formed again. The tenth rib had formed

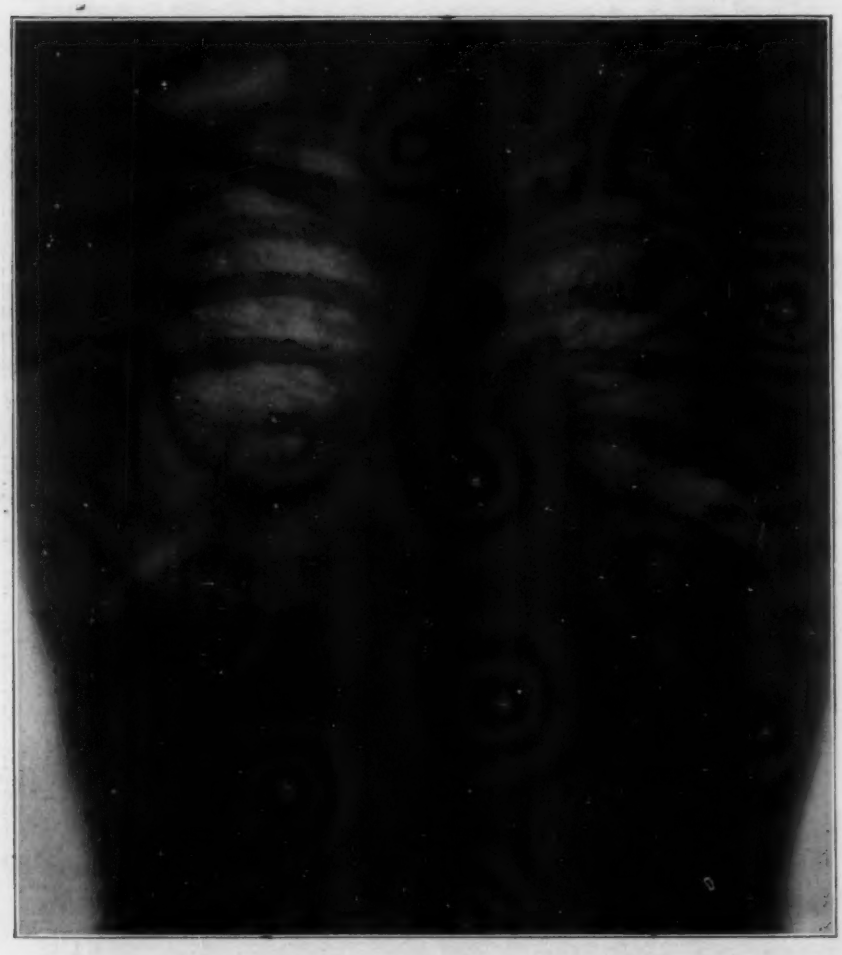

Fig. 29 (Case 8).—Appearance six months after operation; complete restitution to normal; lung fully expanded.

again only to a slight extent; both were resected, extending about 3 inches (7.6 cm.) more than the old operation. Thus an area of pleura 2 inches(5 cm.) wide and 6 inches (15.2 cm.) long was exposed. An aspirating needle was introduced into the middle of this area. Its introduction was impeded by considerable toughness of the wall, but when this had been overcome the point moved freely as in an open cavity. Aspiration drew nothing but air and this did not smell foul. An incision revealed that the knife had cut through lung tissue. A cavity

about the size of two fists was opened and portions of its outer wall excised. The cavity was lined with a smooth tissue. Several trabeculi, some of which carried fairly large vessels, projected into the cavity. The cavity showed the opening of several bronchi and pus could be seen entering through them. The cavity was then packed and a large dressing applied.

There was little reaction from the operation, but there were repeated, rather severe hemorrhages that were at first controlled by packing. These hemorrhages gradually became so alarming and so difficult to control that we were afraid of losing the patient. The hemoglobin dropped to 30 per cent. and the red blood cells to 1,500,000. He was therefore again operated on, February 9, four weeks after

Fig. 30 (Case 9).—Fluid level in an old lung abscess cavity mistaken for an empyema.

the first operation. The rib resection was extended further forward from the anterior limit of the previous operation and by deep hemostatic sutures it was possible effectually to control the bleeding. There was rapid improvement in the patient's condition after that. He has remained well, has no cough or sputum, but he has an open lung abscess cavity lined with epithelium. It is recognized that the patient's condition is not an ideal one, but he feels well and has gained weight and strength. There is no disagreeable odor about him. The wound simply secretes mucus and is easily taken care of. No further surgical treatment has been proposed to him.

The pus from the lung abscess showed gram-negative, actively motile bacilli which were not definitely identified. Microscopic examination of the outer wall of the cavity showed it to consist largely of dense fibrous tissue which was rather poor in cells and showed areas of hemorrhage and hyaline necrosis. It contained a small amount of smooth muscle and many proliferating bronchi, which were often surrounded by zones of small round cells. The bronchi varied considerably in size and shape and were generally lined by a single row of low cylindrical, cuboidal or flattened cells, which showed no tendency towards independent invasive growth. The lumina of many of the bronchi contained desquamated cells

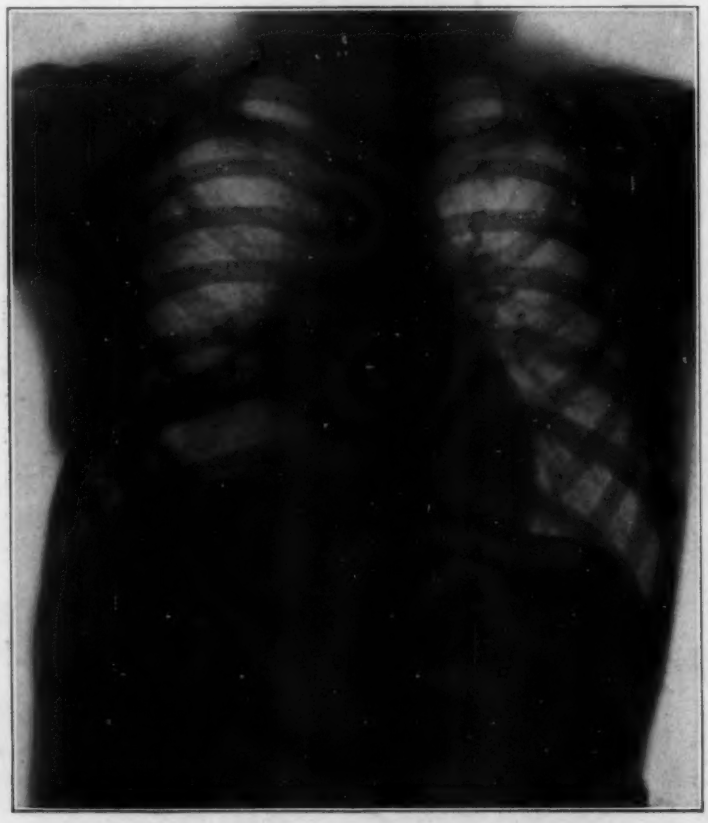

Fig. 31 (Case 10).—Fluid level in old lung abscess of twelve years' duration.

often mixed with blood. One surface of the fragment was covered in two areas with a thick layer of granulating tissue showing a superficial zone of necrosis and suppuration and a deeper and wider zone which was richly infiltrated with small round cells. In other areas it was covered with stratified squamous epithelium showing a slight grade of atypical proliferation. There were no lung alveoli in the sections examined.

The following case is similar in character to the foregoing in that the patient carried an old lung abscess for almost twelve years before it was recognized and treated.

CASE 10.—F. J., a boy, aged 12 years, was first operated on by me for acute empyema when only 3 months old. He was extremely sick and offered little chance for recovery. There was no indication of an intrapulmonary focus at that time. He healed after several months. No roentgenogram was taken. He was lost sight of and did not again come under my care until October, 1922, when 12 years of age.

Since the empyema operation he had many attacks of pain in the right side, with coughing, fever and considerable expectoration. These attacks usually were diagnosed as pneumonia. He had to be kept out of school almost every winter because of these attacks of so-called pneumonia, being a delicate child who apparently was unable to withstand any exposure.

Examination showed chest expansion limited on the right side. In the region of the empyema scar over the eighth rib posteriorly there was dulness extending as far as the angle of the scapula, with diminished fremitus and voice. No signs

Fig. 32 (Case 10).—Fluid level when patient was lying on normal side.

of a cavity could be made out. Roentgen-ray examination showed a large cavity with fluid level in the lower lobe (Figs. 31-32). The temperature on admission was 102.4, pulse 114, and respiration 28. The sputum showed gram-positive diplococci. Operation was decided on and was carried out under general anesthesia. A portion of the eighth and the ninth ribs was removed. The intercostal tissues were ligated at either end and removed. The parietal pleura was opened and stripped away from the underlying lung, which was extensively adherent to it. The lung looked pinkish and felt soft on its outer surface. In the depth a hardening could be felt. Two or three punctures for pus were negative. An additional inch (2.5 cm.) of the posterior ends of the eighth and the ninth ribs was then removed and the lung exposed farther back, but in spite of that we were unable definitely to make out the abscess. Almost the entire lower lobe was then separated from the chest wall, from the mediastinum and below from the diaphragm. With the lung between the fingers a thickening could be felt toward the hilum. The lower edge of the lung was lifted up with sponge holders, the

needle was inserted on the under surface of the lobe toward the mediastinum, and the cavity was entered. Thick pus with very little odor was obtained. The opening was enlarged with a Paquelin cautery, and then, with a finger, a large smooth cavity the size of a fist was entered. With a finger in the cavity a counter-incision was now made through the outer surface of the lung and a tube was inserted into each opening and sutured in place. Blood and pus exuded from the

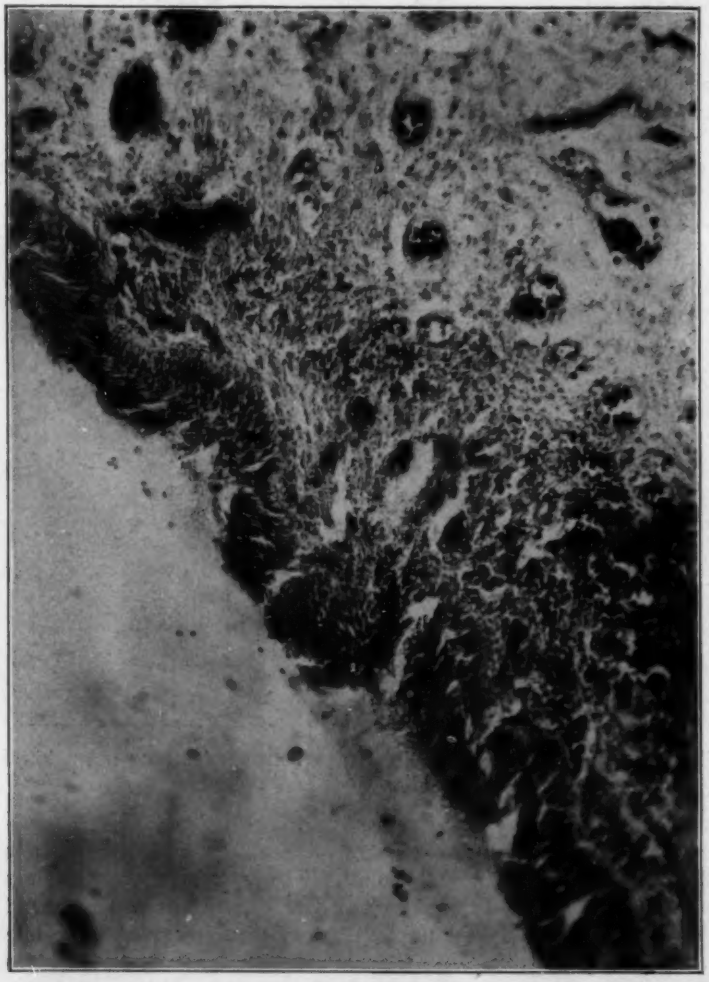

Fig. 33 (Case 10).—Section of wall of old lung abscess cavity and surrounding tissue, showing proliferating bronchioles and epithelial lining of cavity.

patient's mouth and nose. A small tampon was inserted into the abscess cavity and three tampons were packed outside the lung to favor collapse of the cavity. Muscles and skin were partly closed. The patient stood the operation well.

The culture of pus showed gram-negative bacilli with the morphology of the influenza bacillus, but they could not be positively identified because of inability

to grow on different mediums. The pathologic report of the excised lung tissue showed inflammatory lung tissue from the wall of a bronchiectatic cavity. The tissue consisted of lung showing overgrowth of fibrous tissue, fibrous thickening of the alveolar walls and ectasia of the bronchi and bronchioles. The lung tissue showed large areas of hemorrhage and the thickened alveolar walls were infiltrated with many inflammatory round cells. Some of the alveoli were partly

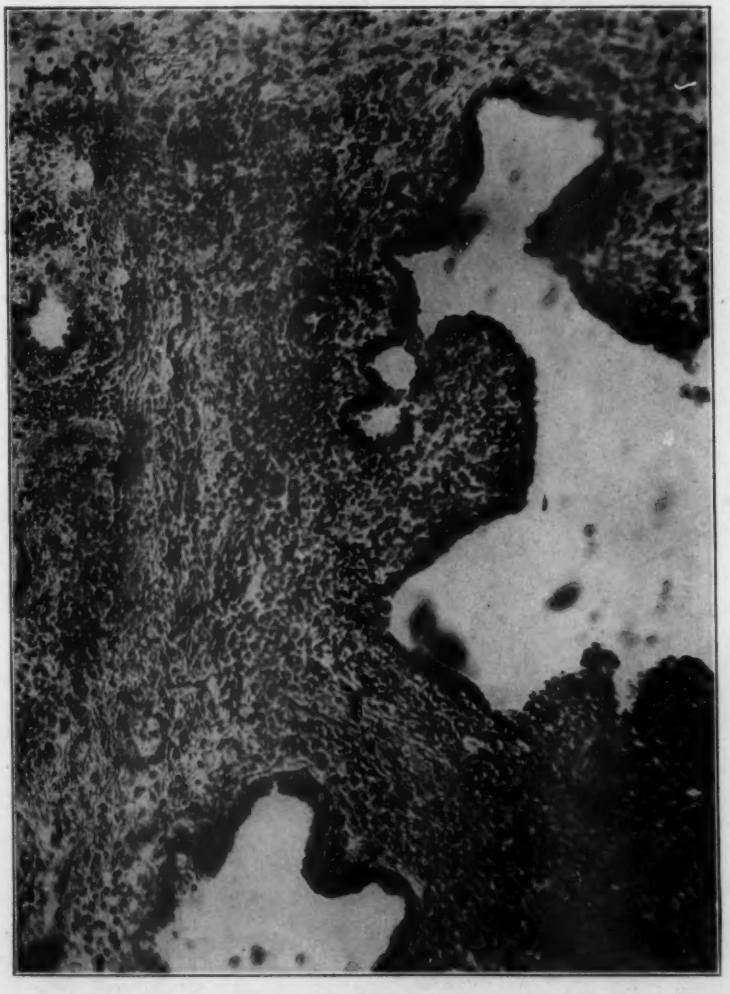

Fig. 34 (Case 10).—Section of wall of old lung abscess cavity and surrounding tissue, showing proliferating bronchioles and epithelial lining of cavity.

or completely filled with desquamated endothelial cells. One surface of one of the larger fragments was covered with thickened pleura. The opposite surface was covered partially with stratified cylindric bronchial epithelium beneath which there was a thick layer of fibrous tissue. This thickened and enlarged bronchus showed superficial patches of necrosis and diffuse hemorrhages in the deeper part of the wall. There were no lung alveoli in the sections examined. There was

no evidence of tuberculosis. Another piece of tissue showed edematous fibrous tissue containing many proliferating bronchioles surrounded by hyperplastic smooth muscle (Figs. 33-34).

Three months after operation there apparently was no tendency for diminution in the size of the cavity as indicated by a bismuth injection (Fig. 35). It appeared to us that we were dealing with an old chronic abscess cavity, the walls of which had become so completely epithelialized as to prevent obliteration.

Fig. 35 (Case 10).—Appearance of lung abscess cavity on injection of bismuth three months after operation, showing that cavity has not diminished in size.

Another operation was therefore decided on for the purpose of destroying the lining epithelium or to marsupialize the cavity. January 25, the patient was therefore anesthetized with ether and an incision made along the old scar surrounding the opening. A portion of the tenth rib was resected, together with the reformed bone in the bed of the ninth and the eighth ribs. The lung was again separated from the diaphragm and the mediastinum. It did not expand with

respiration, but seemed to be entirely fibrosed. The fistulous tract was followed into the lung abscess cavity and the opening was widened. It contained some pus. The cavity was split wide, the lung tissue being thin over the apex of the cavity and becoming gradually thicker toward the sides. There was no air escape from the cut along the lung margins but rather free bleeding which could be controlled only by hemostatic suture. The entire opening was therefore

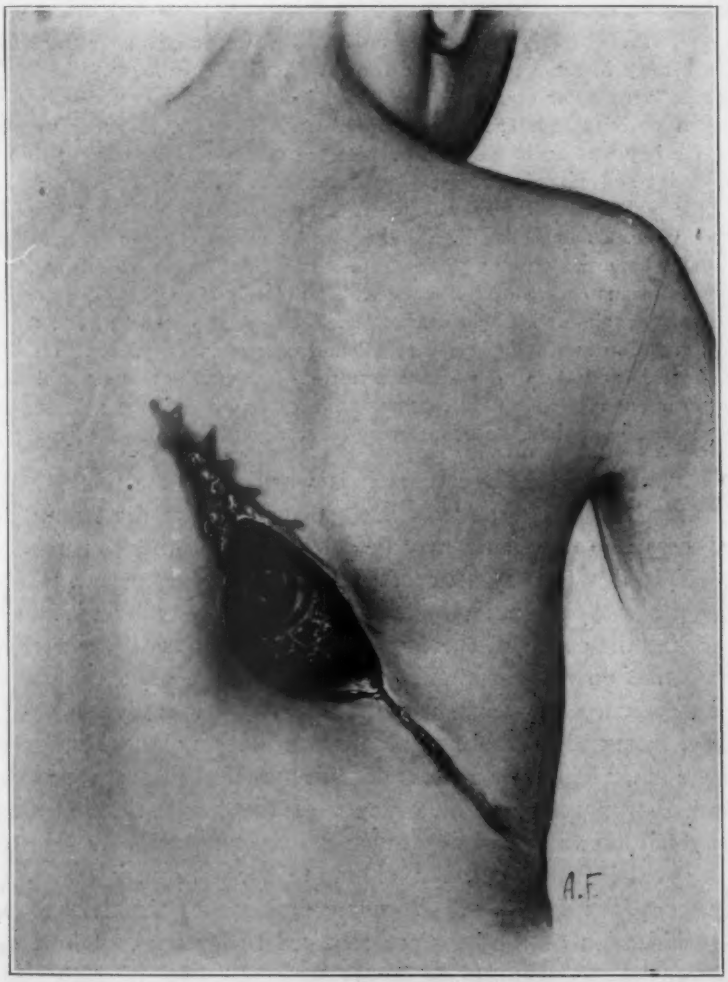

Fig. 36 (Case 10).—Final results, showing old lung abscess lined with epithelium, communicating freely with the outside; several bronchi may be seen in the cavity.

sutured with interrupted catgut, leaving an opening into the abscess about 3 inches (7.6 cm.) long. The lining of the cavity was smooth and velvety with trabeculi running through its wall. It looked much like a trabeculated bladder. Two bronchial openings could be distinctly seen and a probe was inserted into one of these for a distance of 4 inches (10.1 cm.); this set up violent coughing. One

smooth strand of tissue passed directly through the cavity, perhaps carrying blood vessels. It was ligated near either end, removed and sent to the laboratory for examination. Traction on the suture lines around the margin of the cavity now brought the edges up to the skin surface and by means of interrupted silk sutures this margin was sutured to the skin and muscles, thus marsupializing it. A split rubber drain was inserted between the sutures above and a gauze strip between the diaphragm and the outer wall of the cavity. The cavity itself was packed with iodoform gauze.

The boy reacted nicely from this operation, but two months later there was no material change in the appearance of the cavity, which could easily be inspected through its large outer opening. The cavity looked clean, secreted only a small amount of mucopus, and gave no discomfort. However, in order to attempt closure the boy was again anesthetized for the purpose of destroying the lining of the cavity and favoring closure by granulation. The lining of the bronchi and of the wall of the cavity was partly cauterized with the Paquelin cautery but there was such excessive bleeding set up whenever the cautery entered the tissue that it became alarming. The bleeding could not be controlled by pressure, but only by means of hemostatic sutures. The attempt was therefore abandoned and the cavity packed with iodoform gauze. The boy has made a good recovery. He has grown strong, and plays baseball and other athletic games. He has no cough or colds and is in all respects a normal boy except that he still has his large open pulmonary cavity which communicates freely with the skin and which requires a change of dressing about every other day (Fig. 36).

In commenting on these cases it is worthy of note that all of the patients recovered. It suggests itself therefore that the rupture of a lung abscess into the pleura may be considered a rather favorable outcome. This is especially true of the abscesses that perforate slowly and give the overlying parietal pleura an opportunity to become adherent, thus limiting the extent of the exudate. It is also true of the peripheral abscesses that do not communicate directly with a bronchus, for they form an ordinary empyema, and drainage of this empyema will lead to a cure, frequently without any indication that an abscess had existed. If, on the other hand, the abscess does communicate with a bronchus, a pyoneumothorax results, with collapse of the lung, which is a more serious condition and requires a much longer convalescence. However, these bronchial fistulas usually obliterate spontaneously and do not require secondary operation. Adequate drainage of the thorax and at times mobilization of the lung are required to bring about healing, as pointed out by me in an article on the treatment of bronchial fistulas.[7] The most severe cases and those in which the patients no doubt sometimes succumb from the immediate effect of the perforation are represented by my Case 2, in which the abscess ruptured suddenly, producing an acute pyopneumothorax.

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7. Eggers, Carl: The Treatment of Bronchial Fistulae, Ann. Surg. **72**:345 (Sept.) 1920.

DISCUSSION ON THE PAPERS OF DRS. MEYER AND EGGERS

DR. ADRIAN V. S. LAMBERT, New York: In speaking of diseases of the lungs it has always seemed to me that we should be pretty dogmatic and rather pedantic in the use of our terms. I think we all should try to use them with a good deal of discrimination. Dr. Meyer's case of gangrene of the lung presents to me a unique story for that condition. The cases of gangrene I have been familiar with are those in which the patients have gone from rather light illnesses to being desperately ill, in a matter of a few days or a few hours, and I have not met with a case that has lasted as long as this one.

The peculiarity of the gangrene of the lung which I have seen has been that the lung which is involved, is involved over a wide area and has been unaccompanied by adhesions over that area. I have explained it from the fact that the lung was dead and that the formation of the adhesions required two surfaces to unite, both of which should react to the infections.

Other adhesions I have noted in gangrene have been peripheral along the line of the interlobar fissure and have isolated cavities in two large sections, the entire upper lobe being isolated from the entire lower lobe. The sputum as I have seen it associated with gangrene is quite distinct and quite different from that of a lung abscess. It appears more like dirty dishwater, with an extremely offensive odor, similar in character to that of the lung abscess. I have not seen a case of gangrene which assumed the history of a sudden evacuation of thick foul smelling pus. My experience with gangrene has been most unfortunate from the standpoint of curing. I have only one case which has done well in six which I have seen. They all run as I say, a very acute course. In operation on them the adhesions are slit only along the periphery of the gangrene lobe. In one case in which the patient did recover, during convalescense large pieces of the lung were exuded before the patient eventually recovered.

My experience with the lung abscesses that have ruptured into the pleura has been similar to, although not as varied as that of Dr. Eggers. We have had some that have had adhesions and in each case we have had a suppurative empyema. The draining of the empyema with the draining of the lungs at the time of operation has resulted in ultimate cure.

DR. FREDERICK T. LORD, Boston: Both speakers have referred to pneumonia as a cause of abscess and gangrene. I have recently reviewed our experience with 227 cases of pulmonary abscess. The aspiration of infected material from above into the deeper parts of the respiratory tract appears from this series to be the chief cause. A stormy onset in twenty-eight (12.3 per cent.) suggested an etiologic relation to lobar pneumonia, but the grouping of the symptoms of onset and their evolution did not speak for an origin in lobar pneumonia in more than a few instances. Viewing the matter from the experience with pneumonia, our observations accord with those of others and indicate that true lobar pneumonia very rarely terminates in abscess. An origin in bronchopneumonia is uncertain and such initial symptoms as occur may as well be regarded as due to the developing abscess as to bronchopneumonia. On the whole, abscesses arising as a sequel to or unrelated to operation occur so frequently apart from true lobar or obvious bronchopneumonia as to suggest that they are not to be regarded as accidents of resolution, as ordinarily

believed, but as independent infections. The cause of the infection is not as yet clear. We have not as yet succeeded in demonstrating spirochetes in sufficient numbers to suggest that they are to be regarded as of importance in etiology.

Dr. Evarts A. Graham, St. Louis: In regard to the etiology of lung abscess I feel convinced that some of the cases, especially those associated with extensive pulmonary gangrene, probably begin as pulmonary infarcts. It would seem to me that this explanation would be particularly applicable to those cases which occasionally follow an abdominal operation. Of course the factor of aspiration cannot be definitely excluded in these cases; yet I have seen a few cases of lung abscess develop after laparotomy in which it was possible to make out by roentgen-ray examination a beginning triangular area of density very suggestive of an infarct from pulmonary embolism. Moreover, it would seem to me that those cases in which the abscess is situated at the periphery of the lung would perhaps be more easily explained on a basis of embolism with resultant infarction than by aspiration. If a septic infarct has occurred, it is easy to understand how gangrene of that portion may follow.

In my experience the majority of patients with lung abscess spontaneously associated with an empyema get along very well by simple treatment of the empyema itself. This condition means that the abscess has broken into the pleural cavity and usually it has provided adequate drainage for itself in that way. If, therefore, the pleural cavity is properly drained the abscess of the lung will generally take care of itself. Like Dr. Eggers, I also have found it necessary at times to treat the large cavities remaining in the lung after a pulmonary abscess by more radical measures.

Dr. Howard Lilienthal, New York: Lung abscesses have many causes. The first is infection through the blood stream from a hematogenous abscess. This usually occurs as a result of operations in other parts of the body on indurated and suppurating tissue. The organisms get into the blood through the mouths of the severed veins which are held agape by the surrounding induration. These abscesses usually are bilateral and frequently are multiple. They are occasionally mistaken for atypical pneumonia and are as a rule fatal. Occasionally, however, there are single or discrete abscesses of this type that can be treated surgically. Solitary abscesses often progress for a long time without showing signs that may be ascribed to thoracic causes. There may be no cough until the abscess tends to break into a bronchus. When this perforation has finally occurred the diagnosis is simple. Hematogenous abscess has a much better chance to get well without complications if it can be evacuated before it has perforated into a bronchus; the reason of this is that with each cough or strain on the part of the patient the walls of the abscess bulge toward each other, thus tending to obliterate the cavity. If there is a bronchial opening this bulging is not so marked because much of the air escapes through the fistula.

Another form of lung suppuration may be described under the name of aspiration abscesses. These are caused by the mechanical plugging of bronchi with or without infection. The infection will be implanted in any event and a type of suppurative bronchiectasis is the result—not true abscess. Another form of pulmonary suppuration is that which is due to obstruction of the bronchial current by extrabronchial masses, such as tumors. The mechanics is practically the same as though the bronchi were plugged from within.

Most conditions of pulmonary suppuration are combinations of several forms and an individual case will take its descriptive name from the type which

predominates. My principal reason for discussing this question is to arouse an interest in the early operation of hematogenous abscess before evacuation by the bronchus.

DR. CARL A. HEDBLOM, Madison, Wis: In my experience a history of pneumonia has been elicited in a large proportion of the patients who present themselves with a pulmonary abscess. Whether the pulmonary infection that precedes the development of an abscess should be called pneumonitis or pneumonia seems to me largely a matter of terminology. The symptoms certainly in a large proportion of cases are such as would ordinarily justify the diagnosis of pneumonia.

One etiologic factor to be taken into account in cases of abscess that develop without obvious cause is a latent infection in the lung. Perhaps the most outstanding example of such infection that I have observed was that of a man into whose chest wall a piece of wood was driven by a buzz saw. The wound healed and the patient was symptom free for eight years before he developed symptoms of pulmonary abscess. At operation I found a fragment of wood an inch (2.5 cm.) in length in the abscess cavity. Recurrence of abscess months after a drainage operation may also be accounted for, I think, on the basis of latent infection.

DR. SIDNEY YANKAUER, New York: I was particularly interested to hear Dr. Eggers make the statement that pulmonary complications are mostly due to aspiration.

In this connection it is a striking fact that tonsillectomy and other operations about the nose and mouth constantly provide a cause for abscess. In my experience, the last time I counted up my cases, 150 in number, 25 per cent. had had operations on the respiratory tract. This was a larger percentage than that of operations on any other part of the body. This fact alone is evidence that aspiration of infectious material plays a large part in the etiology of these pulmonary complications.

On the other hand, I may recite a single interesting case to show how we can sometimes err in diagnosis. I was asked as a matter of routine to examine a pulmonary abscess, which followed two weeks after the tonsillectomy. When I reached the level of the abscess I found a foreign body in the abscess cavity and it proved to be a thin piece of bone. I inquired of the patient afterward if she had inhaled such a piece of bone and she said she had not. On further inquiry, she told me that at the time of the tonsillectomy an operation had been performed on her nose. I examined the nose and found that a piece of the lower turbinated bone was missing. She probably inhaled it at the time of operation.

DR. FRANZ TOREK, New York: The most striking thing in Dr. Eggers' presentation is the fact these patients all got well. That brings to our mind the fact that a long existence of pulmonary abscess may be a favorable factor in the subsequent operation. We are all aware of the fact that if empyemas are operated on too early they give an unfavorable prognosis. The same thing appears to be the case in abscesses of the lung, because these abscesses which perforated spontaneously and formed empyemas have evidently been opened rather late. As regards the time for operating, therefore, they illustrate quite the reverse of the principle Dr. Lilienthal called attention to, namely, to operate on them before they perforate into the bronchus.

As regards the matter of abscess in the lungs from tonsil operations as a case, Dr. Meyer has called attention to the fact that local anesthesia should

be used as much as possible. I agree with him. But in children its use is impossible. I proposed to a tonsil specialist my idea that it would be wise if every tonsil operation under general narcosis were performed with the head hanging down. He did this and reported to me somewhat later that he was much pleased with the suggestion, and that he is employing it extensively.

Dr. John D. Kernan, New York: I was trying to dodge the discussion of Dr. Meyer's case, because as it turned out he was all right about it and I was all wrong, so it is natural that he should like to talk about it and I should not. It shows that the result of one examination should never be considered in making a diagnosis. Of course I was regarding the case through a bronchoscope, and the bronchoscope gives a narrow point of view. Any one who has ever looked through one will know what I mean.

Dr. Meyer's case had all the earmarks of a lung abscess that could be treated successfully by bronchoplasty, that is, it seemed to be a fairly wide open bronchus discharging pus freely. The roentgen ray appeared to my eye to show a fairly large cavity lined close in where it could be reached by an aspiration tube and a tube for injection; so on these grounds I said, "Let's try to treat the man with bronchoplasty." I don't know yet how Dr. Meyer knew how to do it, but he did anyway and he was entirely right about it, because bronchoplasty treatment would have been wrong. If I had merely aspirated it would not have done any good. If I had tried to inject it or wash it out, I would have been throwing more fluid into the empyema cavity, and putting more pressure on the gangrenous lung, possibly with disastrous result.

Dr. Willis S. Lemon, Rochester, Minn.: I feel the type of case Dr. Meyer has described is that type in which aspiration has grossly occurred. Last year, Dr. Mahle and I reported eighteen of these cases studied at necropsy and found that they varied in their pathologic picture. In the early, rapid cases in which the patients died within a few days, a definite pneumonitis was present. In this pneumonitis one finds many areas in which the lung has apparently been swept out as if by some consuming fire. The only way one could tell a bronchus was present at all was by the fact that the nearby artery could be distinguished and here and there débris found in what would appear to be a bronchus because the nuclei of the bronchial wall were preserved. At a short distance from the necrotic areas, skeletons of the alveoli filled with serum appear, and in their immediate neighborhood the lung was apparently normal, showing that the brunt of the attack was on the bronchi.

In the second type, one finds isolated abscesses of varying sizes and pleuritic adhesions between the separate lobes of the lung, or pleuritic adhesions on the surface of the lung itself. Those of more chronicity would belong to a class Dr. Meyer has described, namely, the type in which an empyema has had time enough to develop.

Dr. Nathan W. Green, New York: I feel that if many of these patients are allowed to wait a little while, they will indicate better the time for operation than if we operate on them when we first see them. I think there is a time in some of these lung suppurations that we feel about as I recall Dr. Elsberg felt concerning the time to operate in fractures of the spine with comparison of the spinal cord. As I understood him, the time when he operated on them was when they began to show signs of temporary improvement. I think the time to operate on these lung suppurations is when they cease going down hill and show a little sign of improvement. Certain of them we know will not get well perhaps without operation, but we think it is safer if we

wait for this slight sign of improvement, at least a stasis in the down grade, and then do the two-stage drainage.

Vital capacity will, I think, help a great deal in determining when to attack these cases.

Much may be said for the expectant treatment of some of these lung abscesses by postural drainage. I think also that palliative treatment is important; it may be carried on by irrigation through the bronchoscope. It is a self sacrificing man that will do it. Dr. Yankauer has done it for a number of years, and Dr. Yankauer knows well the amount of infection and material that may be blown into his face and eyes. I think there is a certain amount of unpleasantness and risk that a man is not called on to go through in the practice of the treatment of lung abscesses. Our desideratum is to have living patients, possibly not entirely cured, but certainly living, rather than to step in too early and have a mortality which we might otherwise not have.

Dr. Howard Lilienthal, New York: To correct an impression which appears to exist, I may say that the cases in which I advise early operation are those in which the diagnosis has been made by the roentgenogram and the symptoms of the patient. I would again urge the opening of these abscesses before empyema or evacuation by bronchus has occurred.

Dr. Willy Meyer, New York: The cases referred to by some of the speakers were principally due to traumatism. We can well imagine that, for instance, a piece of wood resting in the lung for ten years can start an active process just as a bullet does. We can understand that a piece of the broken nasal septum lying within the bronchial tree will keep up suppuration. But if a hematogenous pulmonary embolism is to produce suppuration of the lung, it must necessarily be an infected thrombus that causes the trouble.

I have stated the detailed history of my patient at our meeting here today for a few special reasons. First, with reference to the etiology of the pulmonary suppuration, if occurring subsequent to an aseptic operation. If the patient was operated on for a noninfectious trouble, like a hernia, an ovarian cyst, etc., if he had an aseptic operation and aseptic wound healing, and if he then developed a lung gangrene, with general or an encysted empyema, he must have aspirated. He must have aspirated from a focus in his own lung or he has aspirated vomited material in the course of general anesthesia. The latter is the more frequent occurrence. It depends on the degree of infection of the aspirated material how severely the lung will become affected. A hematogenous embolism certainly cannot be held responsible in my case. It cannot possibly have produced the trouble.

A second point that prompted me to relate the case reported here was regarding diagnosis. If in future I should have a similar patient under my care with the history that the patient had been ill for weeks with cough and fever after an aseptic operation and undisturbed wound healing, expectorating only a scant amount of sputum every three or four hours with a great deal of effort, and if the roentgenogram showed all the earmarks of a lung abscess, I should not think of a lung abscess primarily, but of an encysted empyema due to aspiration and subsequent gangrene of the lung.

I should like to emphasize again that we all should do as many of our operations under regional and local anesthesia as possible.

From what I have seen in the course of years we should try to cut short these acute cases of lung complication, due probably to aspiration; the patients should be placed under hospital care at the hands of a competent bronchoscopist.

If one hospital cannot give sufficient work to one specialist, let four or five hospitals join hands, particularly in neighboring towns and villages in the country. But let the physicians always call in one man, in whom they trust. Nobody has a right to look into a lung except an expert. He must be so well trained as not to do harm. Of course the best man can have a sad experience and lose a patient. Accidents occur in every specialty. But the average patient must be safe in his hands. If bronchoscopist and roentgenographer work harmoniously with the surgeon and the internist, the best results will be obtained. Team-work is the way to success.

ACTINOMYCOSIS OF THE LUNGS AND CHEST

FRANZ TOREK, M.D.
NEW YORK

REPORT OF CASE

History.—J. P., a man, aged 42, was admitted to the Lenox Hill Hospital, Oct. 27, 1924, with the complaint that in October, 1923, he began to have pain in the left breast posteriorly. This pain became severe in April, 1924, when he also had chills and fever. He coughed and noticed that the sputum contained threads of blood and had a sweetish taste. At one time he coughed up a pint of bloody fluid. Going further back in his history we found that he had coughed as long ago as 1916 when exposed to cold and moisture in the army, and that a moderate cough had persisted ever since. He also mentioned that in the last years of the war he, as well as other badly starved German soldiers, on finding a dead horse or other animal, would pounce on it and cut off whatever meat they could get to feed on. He ventured this information as a possible explanation of the origin of his actinomycosis.

About the time of his rather copious hemoptysis, which occurred in April, 1924, he developed stiffness in his neck and was sick enough to remain at home for two weeks. But he went back to his work of handling fats in a slaughter house, and two weeks later, on waking, the stiffness was gone, but a large swelling had appeared in the front of his neck, above the clavicle and in the suprasternal notch. At first this was not painful but in nine days became so. This part of his history evidently indicates that the process in the neck started in the deeper parts and worked its way to the surface. A week or so later, June 6, he was operated on at Bellevue Hospital, a large amount of bloody fluid being removed through an incision in the neck. Meanwhile, the pain in the chest had disappeared, but the cough remained. Together with this one in the neck, a second, smaller swelling had appeared in front of the sternum, about its middle, which then extended to the right, above the nipple. This had been opened, June 16. Neither of these two wounds had healed. From that time on several small swellings appeared in the right breast; these opened spontaneously but had not healed. Cough, hemoptysis and the sweetish taste persisted. The daily chills and fever disappeared after the operation.

He was discharged from Bellevue Hospital, August 28, and was dressed in the dispensary, his wounds always discharging grayish pus, up to his admission to the Lenox Hill Hospital. He lost 19½ pounds (8.8 kg.) in one year. His appetite was not bad. The bowels were constipated. He had a good deal of thirst. He always perspired, mostly between 3 and 4 a. m. He gave no history of venereal disease. He used to drink much wine and smoke 40 cigarets a day.

Physical Examination.—The teeth were in poor condition; there were marked cavity formation and pyorrhea alveolaris, and the breath was foul. The expansion of the chest seemed retarded on the left side. The entire anterior surface of the chest showed a bluish discoloration. On the right side above the clavicle there was a partially healed granulating area; in the third interspace, a draining sinus with granulating edges. On the left side involving the nipple, there was a circumscribed mass about 4 inches (10.1 cm.) in diameter; this was red, painful, very hard at the edges, and fluctuated in the center. On auscultation, there was prolonged expiration on both sides with a tendency to bronchial breathing in the left interscapular region. Many crepitant râles were present at the left base with some dulness. Anteriorly, there was flatness on the

left side, and breathing was diminished. The first heart sound was impure, almost a murmur; the sounds were regular. The abdomen was tense with no tenderness. The liver was enlarged, about 2 fingers below the costal margin.

Microscopic Examination.—Scrapings obtained from the wounds showed the characteristic radiating, club-shaped bodies at the periphery and branching filaments in the center. The sputum was always negative for tuberculosis and

Fig. 1.—Chest, showing dense mass occluding almost entire left side; upper half of right side shows markedly increased density; diaphragm normal; appearance simulates that of tumor mass in left lung.

actinomycosis. The blood was fairly normal except for the leukocytes and polymorphonuclears, which were increased in most of the examinations.

Roentgenographic Examination.—October 30, roentgen-ray examination (Fig. 1) showed the whole left chest occluded by a dense mass. The arch of the aorta was not seen. The diaphragm was regular. The upper half of the

right side of the chest showed markedly increased density. The appearance was that of a tumor mass.

Treatment and Course.—The treatment given was both medical and surgical. November 6, the abscesses on the anterior wall of the chest were extensively incised, revealing the pathologic changes characteristic of the disease: soft granulation tissue, with fatty degeneration and the formation of pus containing the yellowish actinomyces granules. This tissue was thoroughly scraped out, and some of the diseased skin was cut off. Fistulous openings that led into the thoracic cavity on both the right and the left sides could be seen. As the

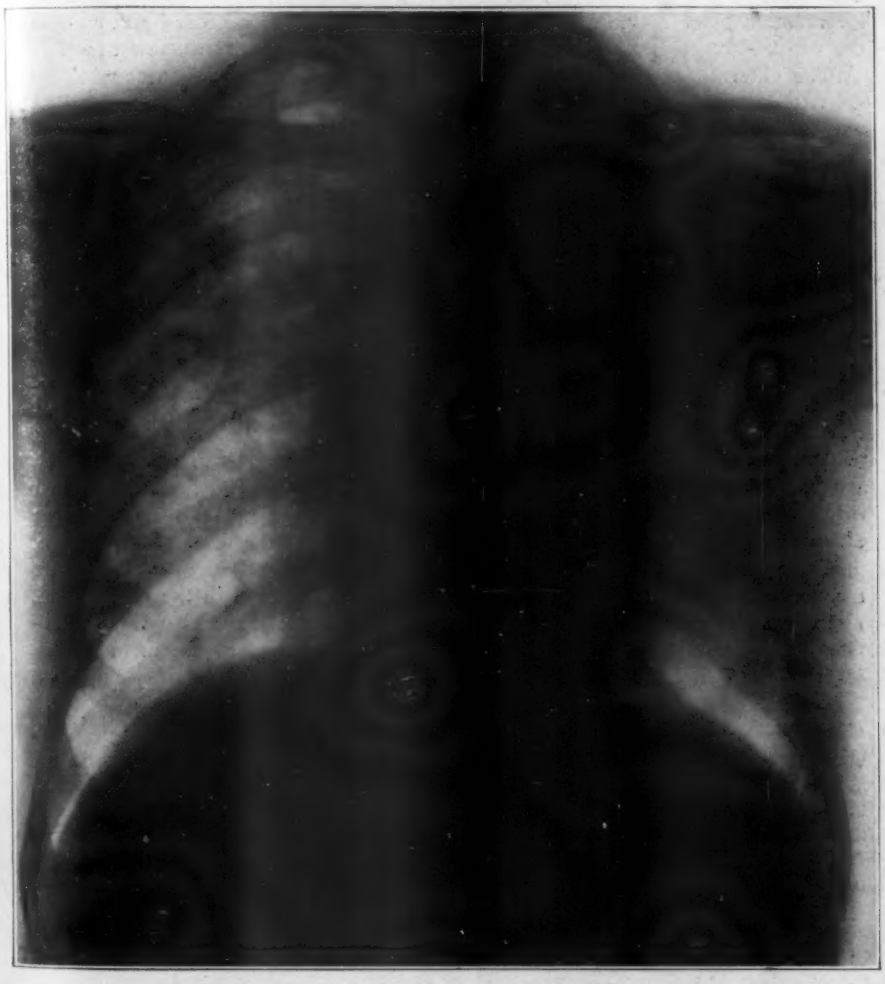

Fig. 2.—Chest showing improvement as compared with Figure 1; right side clearer; on left side lower third has cleared up to some extent and there is diminution in intercostal spacing with corresponding diminution in size of entire side of chest as compared with right; heart and mediastinum drawn over to left (indicative of contraction due to a chronic process on left side); the picture seems to simulate chronic pulmonary tuberculosis.

patient breathed or coughed, the secretions overlying these fistulous openings formed bubbles, proving their communication with the lungs. The fistulas leading into the lungs were not followed up for fear of starting an incontrollable hemorrhage. The wounds were left wide open and packed with gauze. More abscesses appeared on the chest and required further operations, November 29, December 18 and February 2, the last of which was at the right shoulder and arm. The medical treatment, which was started after the first operation, consisted in the administration of iodid of potassium, at first 50 grains (3.25 gm.) three times a day; later 75 (4.87 gm.), and finally 100 grains (6.5 gm.) three times a day. He had been getting the last dose without interruption since Nov. 28, 1924. It was administered altogether by mouth, as the patient objected strongly to the intravenous injection given a few times.

The external affection showed steady improvement, though here and there an extension of the process requiring additional incisions appeared. The roentgenogram taken November 12 (Fig. 2) showed a slight improvement in the lungs. The essential part of the report was as follows: The upper two thirds of the left side of the chest was markedly dense. There was diminution in the intercostal spacing, with corresponding diminution in the size of the left side of the chest as compared with the right. The heart and the mediastinum were drawn over to the left (indicative of a chronic process on the left side). The picture was suggestive of chronic pulmonary tuberculosis.

The last roentgenogram (Fig. 3), taken March 16, showed the cloudiness to be considerable only in the upper part of the left lung, the right lung being almost entirely clear, except for a moderate involvement in its upper part.

All the roentgenograms exhibit a contraction of the left side of the chest and a tendency to replacement of granulation tissue by scar tissue, i. e., a tendency toward healing. Comparing all roentgenograms taken, some of which are not given here, we find this tendency progressive. Thus, when the last roentgenogram (Fig. 3) is compared with the first (Fig. 1), the transverse diameter of the chest is 1 cm. less in the last than in the first. Furthermore, the last picture as compared with the second (Fig. 2) shows the heart 1 cm. closer to the left chest wall in the later picture than in the earlier one. Therefore, not only has the whole chest contracted but there also is an additional contraction of the left lung as manifested by the displacement of the heart to the left.

Reviewing this case critically, we shall first consider the etiology. We know that actinomycosis is acquired mostly through the agency of vegetable material, mainly grain, barley or rye, to the ears of which the fungus adheres. In actinomycosis of the lung it probably enters with the inspired air. In the case of this patient such a source could not be traced. When quite young, he was indeed engaged in threshing wheat, but that was fourteen years before the appearance of even a cough. In one case of actinomycosis of the lung it is asserted that for seven years there were no physical signs except those of bronchitis accompanied by moderate fever, chills and sweating, no infiltration or consolidation being made out during all that time; yet it does not seem possible that for fourteen years the disease could be latent, without any symptoms whatever. On the other hand, transmission from animal to man is exceptional, and, if it occurs, does so mostly in persons taking care of animals afflicted with the

disease; this was not the case, however, with this patient. As to the patient's suspicion that the disease might have been acquired by eating the meat of dead animals during the war, this method of transmission is doubtful, because the meat was not eaten raw but was always cooked, and we know that the ray fungus is killed by a temperature of 75 C.

Fig. 3.—Improvement of right lung, which is almost entirely clear; left lung much improved.

in five minutes. Still, the possibility of infection from this source cannot be dismissed, for the patient must have handled the meat before it was cooked, and actinomyces may have been transferred from the hands to the mouth, and then could have been aspirated into the lungs.

As regards the question whether the disease was primary in the lungs, we know that the affection of the lung may be, and usually is, secondary to an affection in the neck, from which location it may extend upward along the great vessels to the skull, meninges and brain, or downward along the spinal column in the shape of a prevertebral phlegmon causing caries of the vertebrae, suppuration of the costovertebral joints, and extension through the posterior mediastinum to the pleurae and lungs. In his case, however, the neck symptoms, viz., the stiffness, followed a few weeks later by an abscess in the neck, did not manifest themselves until half a year after the marked lung symptoms had set in and about seven years after the chronic cough had begun. We must therefore conclude that this was primarily an actinomycosis of the lung with multiple foci of granulation tissue which broke down into abscesses. Some of these abscesses perforated into the bronchi, causing the hemoptysis mentioned in the history; others perforated the pleura at the apex, forming an abscess in the neck; still others involved the anterior pleura breaking through it. As we had no history or signs of an infected pleuritic exudate, we must assume that there were adhesions between the visceral and the parietal pleura enabling the disease to advance directly through the chest wall to the subcutaneous tissue. Around the abscesses in the lung interstitial inflammation was induced extending over wide areas and terminating in the shrinkage of the lung tissue seen so well in the roentgenograms.

The diagnosis in this case was easy to make because of the antethoracic involvement, with its well developed, old, glistening, yellowish brown actinomyces granules. When these are younger, they are soft, gray, transparent, and not easily detected. Without this external involvement the diagnosis would have been by no means easy. In the earlier stages we have only the symptoms of bronchitis, with cough and expectoration. The sputum by no means always contains actinomyces granules. Even in an advanced stage these may be absent from the sputum. In this case they were never found in the expectoration. Then there are moderate fever, chills and sweating. These symptoms, as also the dulness on percussion, diminished breathing and râles—even the bronchial breathing or signs of cavity formation which may be found—all resemble the signs of pulmonary tuberculosis, as do also the hemoptysis, the thickening of the pleura, and the shrinkage of the lung. Probably the most suggestive hint in the symptomatology is the persistent absence of the tubercle bacillus in the sputum. The roentgen-ray examination does not help in the diagnosis. It may be remembered that the report on the first roentgen-ray examination stated the appearance to be that of a tumor, and the second one was considered suggestive of chronic pulmonary tuberculosis.

The treatment by enormous doses of iodid of potassium internally and by incisions and curetting of the external lesions, the wounds being left wide open, has been mentioned. The cautery and strong disinfectants also are sometimes used.

The prognosis of the affection usually is not favorable. The course of actinomycosis of the lung often extends over a number of years, and the patients usually succumb to exhaustion, partly due sometimes to amyloid degeneration of other organs. A termination in cure is exceptional. In our case we can say only that the patient has undergone a most remarkable improvement, but is still far from being well.

CONGENITAL CYSTIC LUNG*

ROBERT T. MILLER, JR., M.D.

BALTIMORE

The condition named in the title of this article is uncommon and has attracted but little attention. It is a congenital deformity of the lung which may result in grave recurrent attacks of dyspnea and cyanosis in quite early life. The distressing attacks are apparently due to spontaneous rupture of the deformed lung with consequent positive pressure pneumothorax, and may prove fatal. The developmental anomaly of the lung may thus be the indirect cause of death, and although radical surgical measures are hardly to be considered in its management, nevertheless knowledge of the condition and its possible consequences is of interest to the thoracic surgeon.

Congenital cystic lung was first brought to my attention by the following case:

REPORT OF CASE

An apparently healthy child, born spontaneously at term, was brought to the pediatric clinic of the Johns Hopkins Hospital when she was 5 weeks old with the statement that three weeks previously she had suddenly developed an unexplained attack of rapid breathing. The mother stated that at the time the child appeared unable to "catch her breath." Associated with this there was marked cyanosis and an audible wheezing in the chest. The attack was of brief duration and the child recovered, but similar attacks followed, usually about twice a day and lasting from fifteen to thirty minutes, during which periods the mother stated that "she fought for breath." There had been no fever, and between attacks the child had slept and nursed well. There had been no gastro-intestinal upset. The occurrence of a severe attack with which the child was suffering on admission had induced the mother to seek advice.

Examination on admission showed a well formed and well nourished child. She was acutely ill and in great distress. Respiration was extremely labored. There was marked cyanosis, the lips, fingers, and toes being blue and the face greyish. The degree of cyanosis varied somewhat from time to time, and during the more severe periods the eyes rolled upward. The chest was somewhat asymmetrical, the right upper front not being quite so full as the left. Respiratory movements were small in amplitude, respiration consisting of short quick gasps. There was marked retraction of the lower ribs on the right side with inspiration. On percussion there was decided tympany over the entire right side except for the region above the angle of the scapula, where the note was rather dull. Breath sounds were not audible over the tympanitic area, and were quite suppressed in the suprascapular and supraclavicular regions. On the left side the note was dull over the upper portion of the chest and resonant over the base. There were many râles over the entire left side. The impulse of the heart was

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*From the surgical department of the Johns Hopkins University and Hospital.

diffuse in the left axilla, the point of maximum impulse being in the midaxillary line. The entire area of cardiac dulness had shifted to the left, leaving a narrow strip of tympany between the right border of the heart and the left border of the sternum. The sounds of the heart were clear and forceful, the rate being regular though rapid. There was no fever. The leukocytes were 17,200.

Fig. 1.—On admission, complete pneumothorax of right side (positive pressure).

The condition was thought to be a right-sided pneumothorax with displacement of the mediastinum and the heart to the left. Roentgenograms appeared to support this diagnosis (Figs. 1-3).

Thoracentesis of the right pleural cavity with a fine needle released air under evident pressure and immediately relieved the respiratory embarrassment. Positive pressure in the pleural cavity was promptly reestablished, however, and, after repeated thoracenteses, on the fourth day through a low intercostal space in the

right side of the back a small rubber tube fitted with a one-way valve was inserted, allowing escape but preventing aspiration of air into the pleural cavity. Following this the child's condition improved in a most striking manner. Cyanosis all but disappeared and respiration, losing its labored character, became regular and easy. The child had been saved from impending death and restored to comparative comfort. She nursed and slept well and was entirely free from

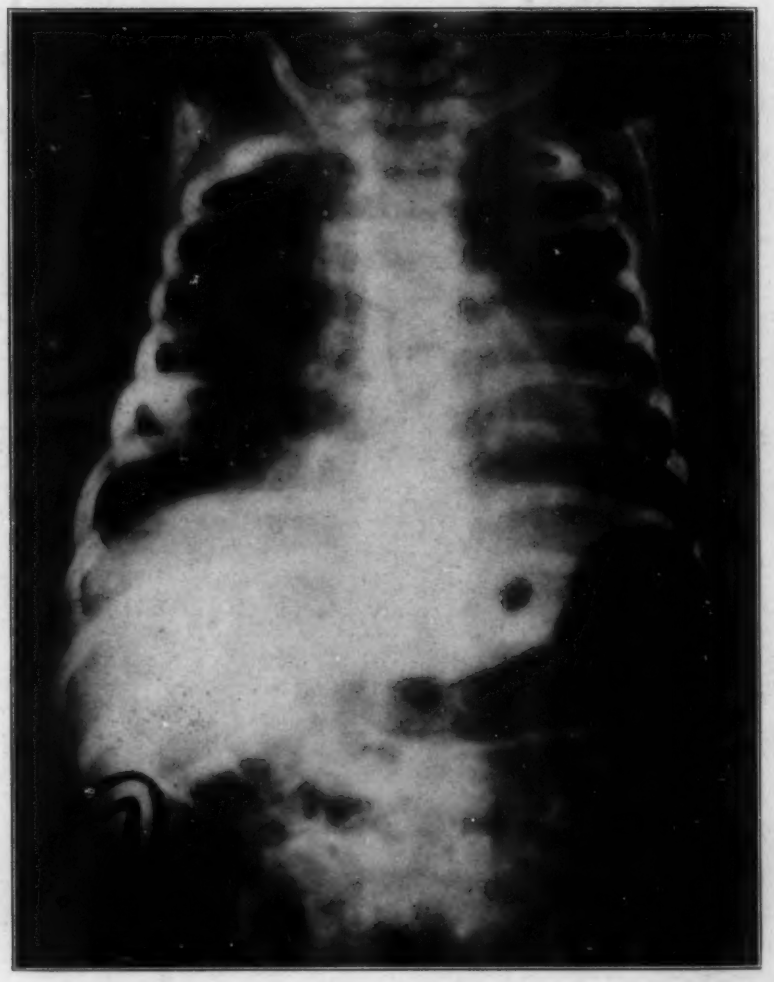

Fig. 2.—Partial pneumothorax of right side: appearance twenty-four hours after removal of tube, a one-way valve allowing exit only, which had been allowed to remain in eight days.

respiratory embarrassment. At the end of a week the tube was removed without ill consequences, and a week later the child was discharged in comparatively good condition. The heart had approached its normal position and the right lung seemed partially expanded, with breath sounds coming through at the base,

though the percussion note over the right side of the chest was still somewhat tympanitic. Although the tube was in place for a week, the child fortunately escaped an empyema.

Ten days after discharge from the hospital the child had another attack, from which she recovered without help, and for about three months she was free from all symptoms except a slight but persistent cough. When five months old she suffered a series of entirely similar attacks of extreme dyspnea and cyanosis

Fig. 3.—Complete pneumothorax of right side fourteen days after removal of tube.

which culminated in death. There was no opportunity to obtain a necropsy since the child was not in the hospital. The clinical diagnosis, therefore, is not confirmed by anatomic findings, but seems secure in view of the physical signs, the repeated roentgenograms of the chest, the progress while under observation, and the similarity of the clinical history to that of certain of the cases of congenital cystic lung which have been submitted to postmortem examination.

Congenital cystic lung is a developmental error, resulting in the presence of air containing cavities scattered through the lung. Not infrequently these are situated on the cortex. Rupture of a cortical cyst which communicates with the bronchial tree causes a positive pressure pneumothorax; such a sequence of events offers an apparently adequate explanation of the attacks of respiratory embarrassment, in particular of their sudden unheralded onset, the extreme degree of dyspnea and cyanosis produced, the spontaneous recovery, and the tendency to recur.

A second example of the condition is presented by the following case occurring in the obstetrical service of the Johns Hopkins Hospital:

Following a difficult instrumental delivery a baby was born in asphyxia. The child was resuscitated with some difficulty, but presented no other abnormality until the fifth day. From this time until death on the twelfth day of life there was pronounced difficulty in feeding; the child did not gain in weight and was finally submitted to exploratory laparotomy though without benefit. Difficulty in breathing was first noticed on the seventh day. On the ninth day the child appeared much improved, had gained steadily in weight and seemed to be in good condition. On this day, however, the baby suffered a "sudden respiratory failure with extreme cyanosis." There was no apparent cause for this attack, which appeared without prodromal signs of any sort. The attack was severe and for six hours the child was in a precarious condition, but finally recovered. On the eleventh day frequent attacks of this sort occurred and the child was kept alive only by artificial respiration. On the twelfth day the respiratory attacks became more frequent and prolonged, finally proving fatal. During each of the attacks cyanosis had been extreme, the two outstanding features being cyanosis and dyspnea to the point of demanding artificial respiration.

At necropsy a moderate amount of blood-stained fluid was found in each pleural cavity and in the pericardial sac. The heart was quite normal, and except for the condition of the lungs a complete necropsy failed to show anything unusual. The lungs contained air and floated. There was marked congestion throughout, and in the right upper lobe a small patch of red consolidation 2 cm. in diameter. In addition a most peculiar picture was revealed: there were few inflated areas and these were principally at the periphery; the rest of the lung tissue was atelectatic or cystic. The cysts were numerous and of varying size, ranging from that of a normal alveolus to 3 mm. in diameter. They were lined with flattened epithelium and when studied in serial sections were seen to communicate with each other but not with the alveoli. The bronchi and bronchioles were diminished in number. In one place there was found a communication between a bronchiole and a cyst. This cyst was one of the smaller ones, and there was a gradual transition from the columnar epithelium lining the bronchiole to the flat epithelium lining the cyst. The bronchioles communicated freely with the alveoli. The area of consolidation noted in the gross description was an area in which the alveoli were filled with blood. There was considerable edema throughout. In some places heart failure cells were numerous. There was a noticeable increase in the interlobular connective tissue and in various places collections of lymphoid elements (Fig. 4).

The first clinical report on this condition was made in 1859 by Meyer [1] in Germany. In his paper there is the account of a third case essentially similar to the two just detailed.

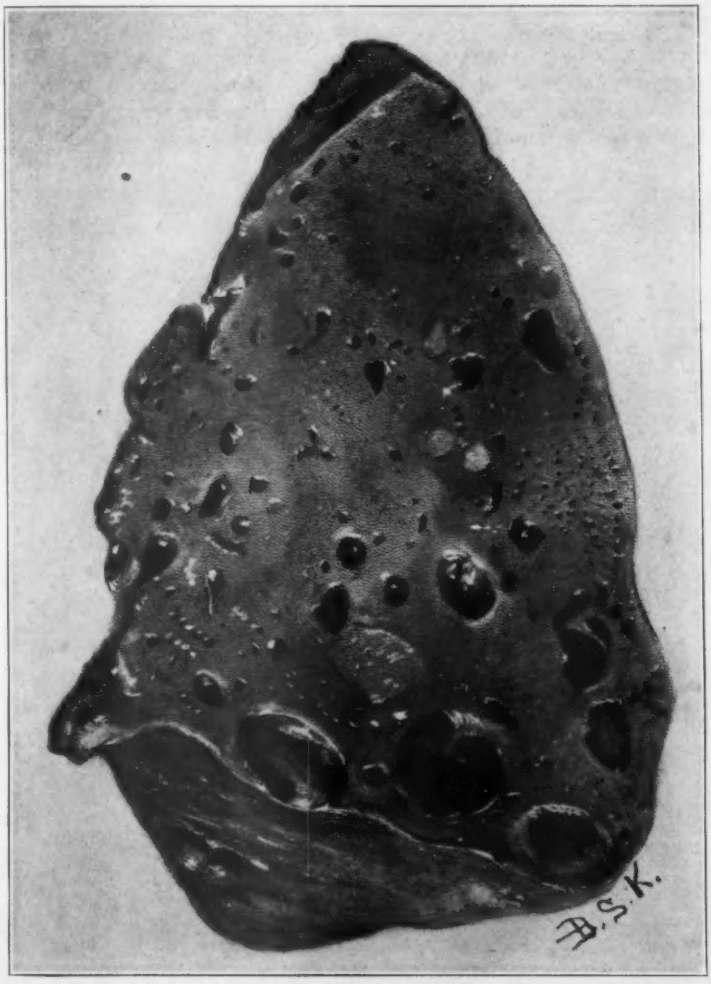

Fig. 4 (Koontz's case).—Gross appearance of lung on cross section.

A child 1 year old had been subject to repeated attacks of severe asphyxia, during which respiration became sibilant, the pulse irregular and stormy, and extreme cyanosis appeared. The first of these attacks occurred in the fifth month of life and was followed by many others, all of the same type and char-

1. Meyer, H.: Ueber angeborene blasige Missbildung der Lungen, nebst einigen Bemerkungen über Cyanose aus Lungenleiden, Virchows Arch. f. path. anat. **16**:78-95, 1859.

acterized by the sudden appearance of extreme dyspnea and cyanosis. Death finally occurred in an attack. Necropsy showed the left lung to consist of two parts, an upper and a lower, which were separated by an hiatus reaching to the root of the lung (Fig. 5). The lower part consisted of three air containing lobes which were normally constructed except for the gross anomaly and together equalled about one-fifth the volume of the right lung. The upper part was formed by a broad, fibrous, thin walled sac containing air and lined by smooth mucosa which toward the hilum of the lung was thrown up into a few large rugae. Inflation of air demonstrated the opening of fine bronchial branches beneath these rugae. The right lung was normal except for the presence on its cardiac surface of a few cortical cavities the size of "peas."

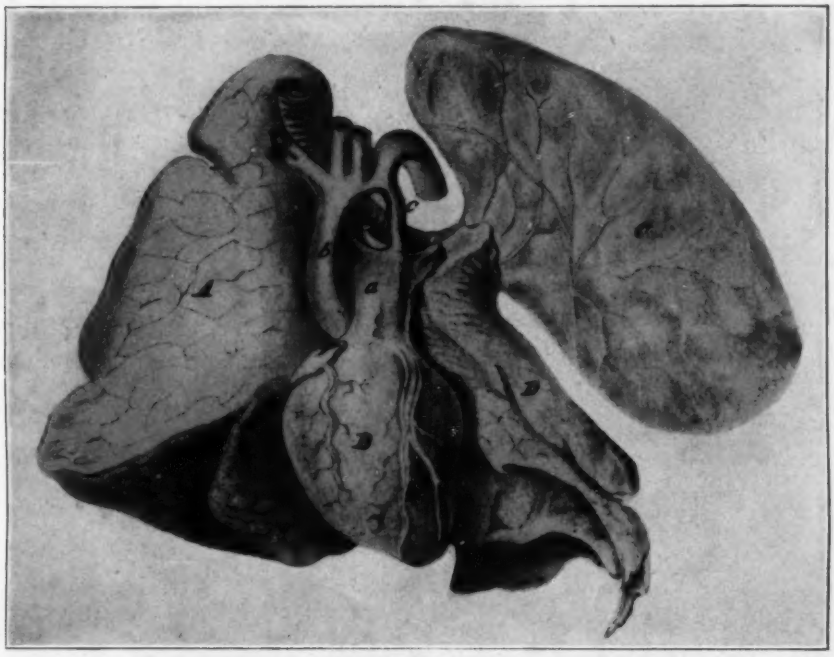

Fig. 5 (Meyer's case).—Normal lung tissue replaced by thin-walled fibrous sac, *C; D,* lower, three lobed portion.

These three cases present essentially the same clinical picture. A sudden unheralded attack of extreme dyspnea and cyanosis occurred during the first six months of life in a well formed child. The attack was notable in its severity. Subsequently at irregular intervals each patient suffered repeated recurrences of similar attacks of asphyxia, ultimately dying in one of them. At necropsy in two of the cases air containing cysts that communicated with the bronchial tree were found in the lungs, and the third case, which occasioned this report, though lacking postmortem confirmation of the clinical diagnosis, presented roentgenograms that were interpreted as representing the same condition.

There were no anomalies in the circulatory system to account for the attacks of dyspnea and cyanosis, and it seems entirely reasonable to assume their cause to have been the rupture of a cortical air containing bleb that communicated with the bronchial tree and the consequent development of a positive pressure pneumothorax, from which each child slowly recovered only to suffer subsequently repeated similar accidents, one of which finally proved fatal.

In the first case detailed here the patient responded to treatment based on the diagnosis suggested and in a way to support our assumption, as

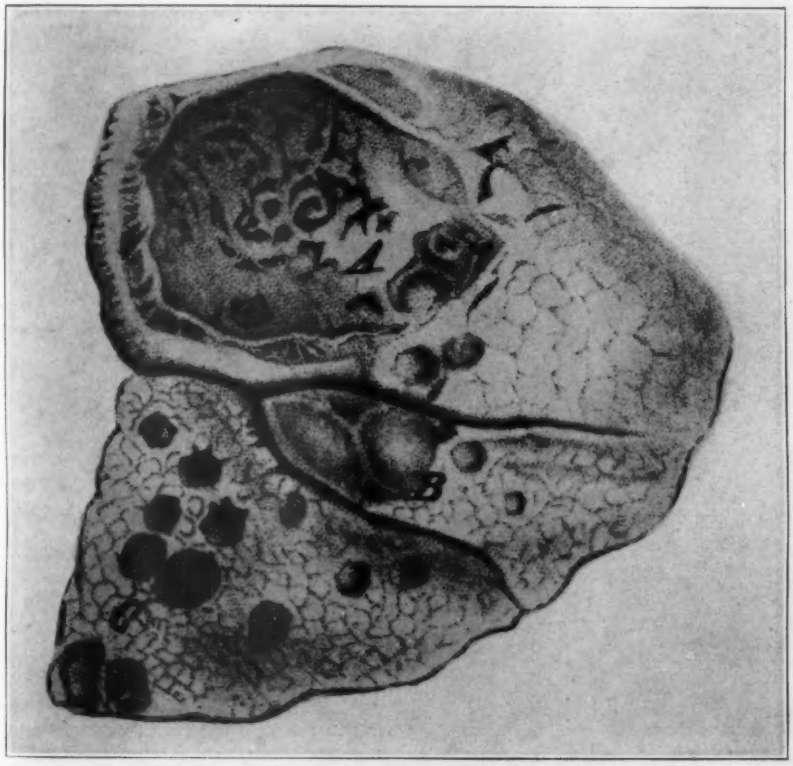

Fig. 6 (second case from Meyer).—Right lung: *A*, upper lobe; *B*, middle lobe; *C*, lower lobe.

reduction of the positive pressure in the pleura resulted in immediate relief of dyspnea and cyanosis. Furthermore, at the end of a week, during which the affected lung was collapsed, it was assumed that the opening in the cortex of the lung had become securely sealed off and that the tube could be removed without immediate danger of the reappearance of positive pressure; the child's uninterrupted recovery after this was done seemed again to bear out our assumption. Each subsequent

attack appeared suddenly and without warning, just as one might well expect with rupture of a cortical cyst. Finally, there is the evidence obtained by roentgenographic study which quite definitely suggests congenital cystic lung, so that the whole picture seems to support the diagnosis. It is of interest that the relief obtained by the insertion of a tube was not marked until a one-way valve had been placed on its external end, allowing the egress and preventing the aspiration of air into the pleural cavity. There seemed in this some similarity to the common experience with sucking pneumothorax.

Congenital deformities of the lung are not common. An anomalous division into lobes is occasionally encountered and less frequently a

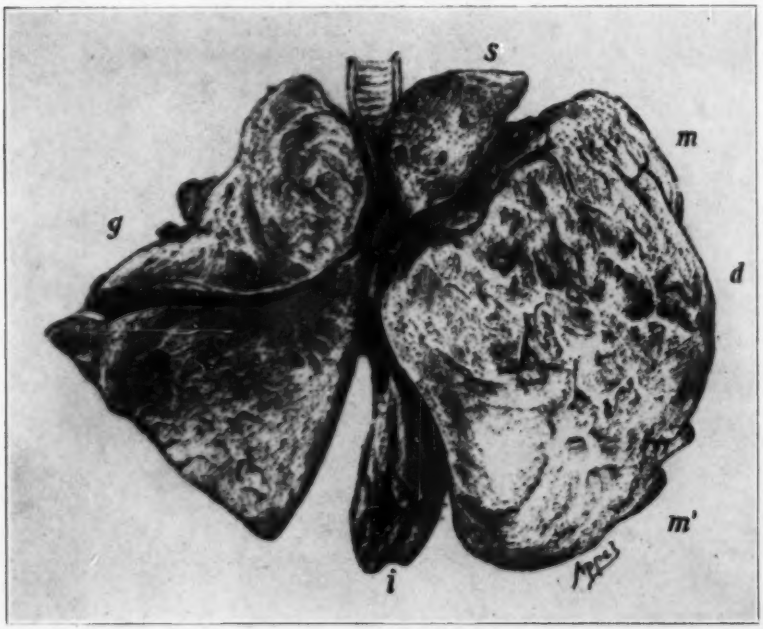

Fig. 7.—Posterior view of pulmonary apparatus: *g*, left lung; *d*, right lung; *s*, superior lobe; *i*, inferior lobe; mm', polymicrocystic middle lobe.

partial or complete absence of one lung. Causing no clinical symptoms, these abnormalities usually escape recognition during life and appear as chance findings at necropsy. Of still greater infrequency is the condition known as congenital cystic lung, in which the finer structure of the viscus is concerned. Normal parenchyma is replaced by air containing cavities lined with mucosa. The alteration may affect a definitely outlined area or the cysts may be scattered diffusely through the substance of the lung. At times the cysts are so numerous and so generally distributed that except for a few widely

separated areas the pulmonary parenchyma is entirely replaced. There seems to be no rule with reference to the distribution of these cysts; some are usually found on the cortex, but the structural change is commonly present to a greater degree throughout the underlying substance of the lung. The cavities vary widely in size and sometimes, as in the case

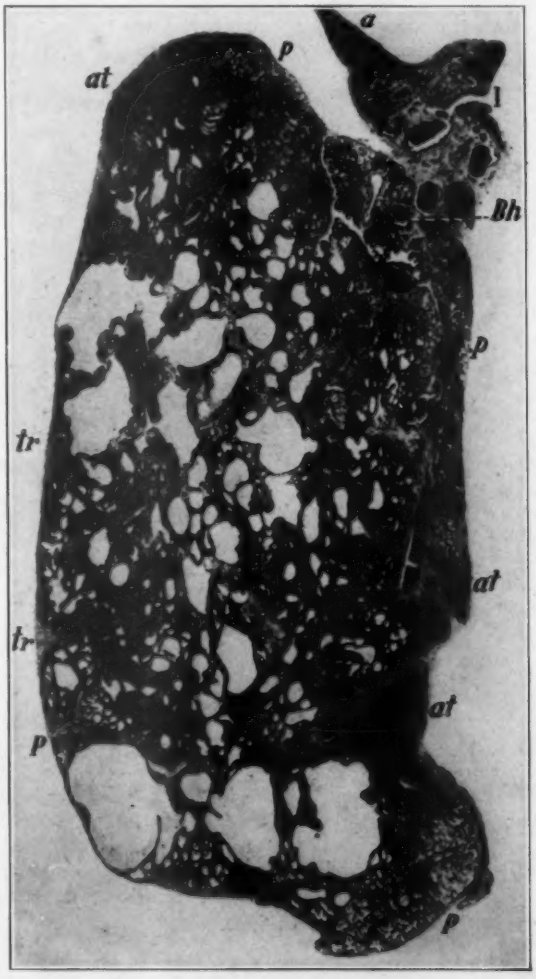

Fig. 8.—Histologic section comprising whole thickness of cystic lobe following horizontal plane passing through hilum: *tr*, interlobular indentations; *p*, normal pulmonary parenchyma; *at*, atelectatic lobules; *Bh*, hilum of middle lobe; *l*, portion of inferior lobe included in section, in vicinity of hilum.

of Meyer presented above, attain the proportions of a huge air containing sac which replaces the larger part of a lung. Occasionally the lungs are normal except for the presence of a tumor-like mass made up

of cysts and attached to one lobe.[2] In one instance such a mass was attached to the esophagus only.[3] The cysts may be separated from each other by thin septums; when they are situated on the cortex just beneath the pleura their walls are at times so thin that spontaneous rupture into the pleural cavity would seem to be largely a matter of chance. In addition to intercommunication between the cysts the entire bed may or may not communicate with the bronchus. The cystic area may contain no pigment, a fact emphasized as proof of congenital origin, but this observation is not constant nor is the proof so adduced of prime importance with reference to a condition so obviously the result of

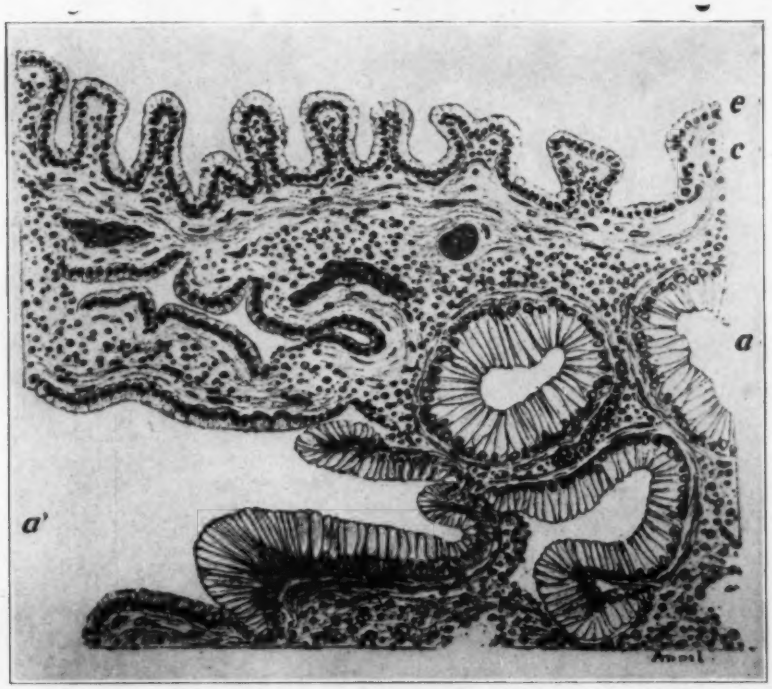

Fig. 9.—Wall of large cyst and adenomatous formations: *c*, cubical epithelium lining a small cyst; *a*, adenomatous formation; a', direct communication between adenomatous formations and cystic cavities.

developmental error. The cysts are lined with epithelium, usually a single layer of cells, which vary from flat cubical to columnar epithelium, being ciliated more often than not. There is apt to be a small amount of mucus and cellular detritus in the cavities; at times they have a fluid

2. Stoerk, O.: Ueber angeborene blasige Missbildung der Lunge, Wien. klin. Wchnschr. **10**:25-31, 1897.

Wechsberg, F.: Ueber eine saltene Form von angeborener Missbildung der Lunge, Centralbl. f. allg. Path. **11**:593-599, 1900.

content, and certain of the larger saclike cysts have been said to contain a considerable amount. The character of content of the cysts, whether air or fluid, probably depends in part on the presence or absence of a communication with the bronchus.

The genesis of this deformity of the lung is quite obscure and has been the subject of much speculation. Many causes have been suggested. Because of the increased susceptibility of an anomalous lung of this sort to intercurrent disease, many patients die of bronchopneumonia; the cavities may then contain more or less purulent material, and because of the additional presence of small abscesses actually the result of the acute disease, the entire condition has been looked on as the end-result of bronchopneumonia. This interpretation, however, is not correct, as the cavities are quite obviously the result of an anomaly in

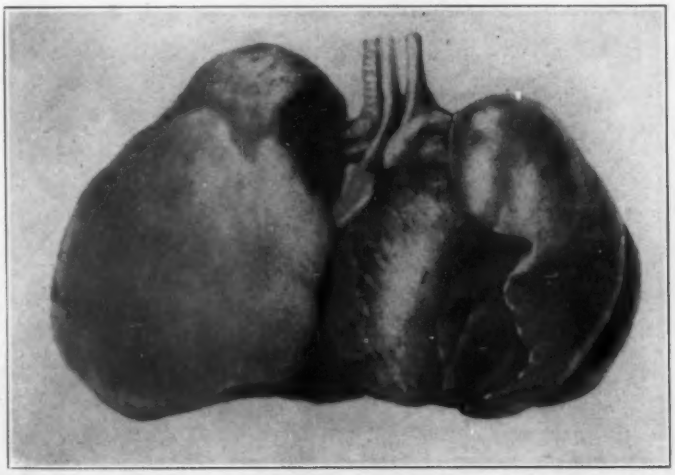

Fig. 10 (Pappenheimer's case).—Heart and lungs; only malformed upper lobe of right lung is seen from anterior aspect (from Studies from the Department of Pathology of Columbia University College of Physicians and Surgeons *13,* 1913).

development rather than of acquired disease. A retention of secretion whose escape is blocked by strictures of the bronchioles, or by rugae thrown up by the mucosa, has been frequently mentioned; this can hardly be the actual cause, since a communication with the bronchus has been demonstrated frequently; the epithelium is not always flattened; there is no apparent pressure atrophy of the intervening septums, and the secretion found in the cavity is not sufficiently great in amount to cause distention. Certain French authors have gained the impression that the condition is associated with congenital syphilis, but the occurrence of syphilis is not constant, and the coincidence of the two conditions

appears to be one of chance rather than of cause and effect. Couvelaire [4] has suggested that the same factors are concerned as in the genesis of congenital cystic kidney. Virchow [5] regarded dilatation of the lymphatics as the explanation. Stoerk [2] believed the condition to be neoplastic, and used the term fetal cystic bronchial adenoma. In certain of the cases collapsed tubular epithelial projections leading from the cysts and resembling glands are described; these structures provoked Stoerk's suggestion, but their occurrence is apparently not constant nor do they appear to be an essential part of the lesion.

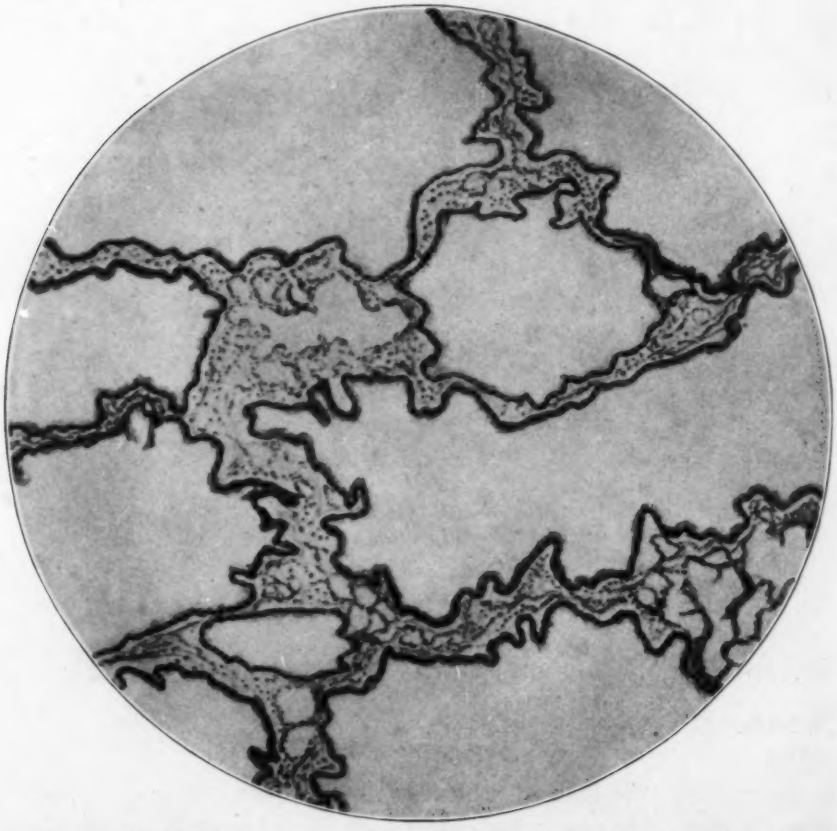

Fig. 11 (Pappenheimer's case).—Section through right upper lobe; dilated bronchioles lined with ciliated epithelium; normal alveolar tissue in the septums; × 80 (from Studies from the Department of Pathology of Columbia University College of Physicians and Surgeons *13*, 1913).

4. Couvelaire: Dégénérescence kystique congénital du poumon. Histogénese des dégénérescences kystiques congénitales des organes glandulaires (rein, foie, pancréas, poumon), Rev. mens. d. mal. de l'enf. **22**:60-77, 1904.

5. Virchow, R., in Kaufmann: Lehrbuch der speziellen pathologischen Anatomie, Ed. 1911, **1**:227.

The change apparently affects the finer bronchioles. In the walls of the cysts and scattered through the intervening tissue there is apt to be a certain amount of cartilage and smooth muscle. These two elements may show some semblance of orderly arrangement but usually are quite irregularly distributed. It is to be noted that the condition does not affect the larger bronchial branches and is to be distinguished from bronchiectasis. It is sometimes designated bronchiectasis teleangiectatica [6] or bronchiolectasis.

The attempt to establish a causal relationship to possible etiologic factors such as those mentioned is purely speculative and probably of little profit. No one of them would have been suggested without reason, and yet no one of them offers an adequate explanation. Congenital cystic lung is obviously a developmental error; its cause, however, is altogether obscure. The peculiar character of the anomaly is perhaps determined by the fact that the disturbance in growth occurs at a particular period of embryonic life. The condition is to be kept in mind as a congenital pulmonary deformity which in early life often causes recurring sudden severe attacks of cyanosis and dyspnea, which may prove fatal. Radical cure is manifestly out of the question, yet it behooves the thoracic surgeon to have some acquaintance with congenital cystic lung since prompt thoracentesis will avert the fatal consequences of acute pneumothorax, an accident constantly threatening the life of these patients.

In order to summarize briefly the pathologic changes found in congenital cystic lung, Figures 4 to 11, copied from the articles of a number of those who have written on this subject, are reproduced here.

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6. Grawitz, P.: Ueber angeborne Bronchiectasie, Virchows Arch. f. path. Anat. **82**:217-237, 1880.

PRIMARY CARCINOMA OF THE LUNG

REPORT OF TWO OPERATIVE CASES *

HAROLD BRUNN, M.D.
SAN FRANCISCO

From the surgical standpoint carcinoma of the lung has presented so many difficulties that of all organs of the body attacked by this disease it has been the last to give way to surgical intervention. The reported cases of operation are as yet small and the results not too heartening.

The difficulties encountered have to do not only with the surgical problems involved, but equally with the peculiar and vicious characteristics of the disease and the difficulty in diagnosis while in the operable stage, owing to the wide variations in its clinical phenomena. On the one hand, we have a disease so fulminating and rapid in its course that death comes in a few weeks. Again metastases have widely taken place before the lung phenomena have expressed themselves in diagnosable form. On the other hand, its course may be so insidious and symptomless that the patient seeks medical advice only when it is already too late for operation. Increased operability must therefore come through improvements in surgical approach and through better and earlier diagnosis. Many reports show that delay or doubts in diagnosis carried cases over to the inoperable stage. My second case report is an instance of this. A more widespread and better understanding of the suggestive symptoms of the disease must be had before surgery can be brought to its full usefulness.

TREATMENT

Since deep roentgen-ray and radium therapy have not proved at all successful in the treatment of primary carcinoma of the lung the one hope for the amelioration of symptoms and prolongation of life, or perhaps a cure, will depend at this time on surgery. And while, as before stated, a number of sufferers are beyond this hope almost from the beginning, there are still left a considerable number who at some stage in the disease might be helped by surgery. It is to bring these cases out into the open that we must bend our efforts. If cases are diagnosed early before metastases have occurred or complications have resulted, surgery may be favorable. Tumors located in the periphery or smaller branches of the bronchi afford some chance of successful operative intervention. This is especially true of those in the lower lobe. Tumors lying in close proximity to the hilum are difficult to

* From the department of surgery, University of California Medical School.

handle by resection but they may be held in check at least by cauterization, using the method developed by Evarts Graham for inflammatory conditions.

I myself believe that the cautery affords the best means for the removal of malignant growths in the lung, as it does in other parts of the body. Lilienthal advocates exploratory thoracotomy when masses are found by roentgen-ray and bronchoscopic examination, followed by lobectomy when necessary. He would extend this exploration to cases presenting tumors and shadows of unknown origin in the chest cavity.

Besides the fifteen cases reported by Sauerbruch, five of which were his own, we have found thirteen others in literature that have been subjected to surgical intervention. Several of these were merely thoracotomies with biopsy removal and drainage for bronchiectatic cavities, and could not by any means be called operations for the purpose of the removal of a tumor. Four of the patients in Eloesser's series in San Francisco were operated on. In two, abscesses were drained; one patient died a short time later from hemorrhage. The second patient was drained because of a diagnosis of bronchiectatic abscess, but died two days later. One patient's chest was opened with the hope of removing the tumor but was found inoperable because it had grown through the diaphragm, and the fourth patient had a diagnosis of bronchiectasis. The bronchiectatic lobe was removed. The patient died twelve hours later. Necropsy disclosed a lymphosarcoma mainly at the hilum. In practically only one, the last case, therefore, was an attempted operative removal made.

Of Sauerbruch's five patients, one died five days later from pneumonia. The second patient had a small carcinoma on the left lower lobe. The patient is still living five years after operation without recurrence. The third patient, with a large alveolar carcinoma of the right lower lobe involving part of the middle lobe, in which a resection was done, died six days later. In the fourth case, the carcinoma arose from the left upper lobe; it was the size of a small fist and was easy to remove. The patient died five days later of pneumonia. In the fifth case there was a well circumscribed carcinoma of the right lower lobe attached also to the chest wall. This patient is still alive three years later.

I desire to report two cases of primary cancer of the lung in which operations were performed within two months of each other. Neither of them, however, was diagnosed sufficiently early to make probable a permanent cure.

REPORT OF CASES

CASE 1.—J. B., aged 56, a contractor, was seen in consultation with Dr. J. B. Sherman at the Mount Zion Hospital. A year before the patient had become subject to morning cough without expectoration. This symptom was not given much consideration until about four months later, in March, 1924, when he also suffered

from attacks of dyspnea associated with dryness of the throat and a choking sensation. These attacks were not always related to exertion. Improvement followed treatment by a throat specialist. Shortly after this he began to have frequent eructations, discomfort in the epigastrium, loss of appetite and loss of weight. About this time, in June, he consulted Drs. J. Marion Reid and Leo Eloesser.

Roentgen-ray examination of the chest (Fig. 1), taken in July, showed a large tumor, filling almost the entire right lower lobe with sharply defined

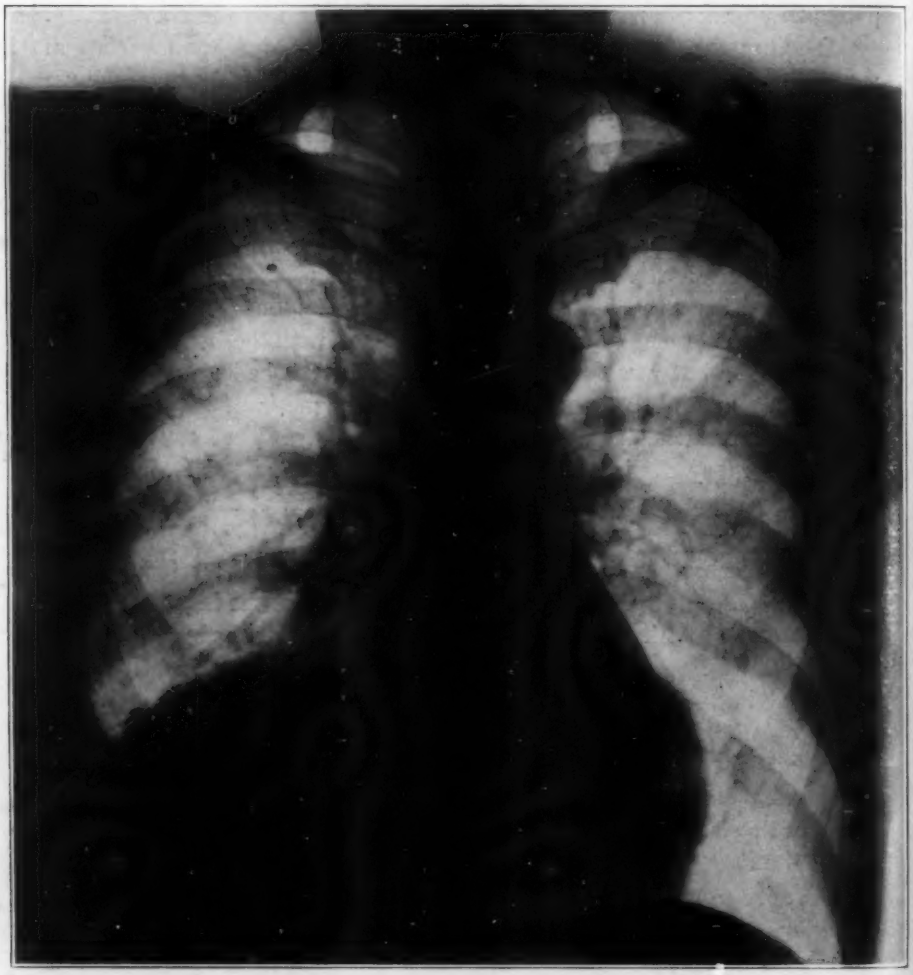

Fig. 1 (Case 1).—June 27, 1924, large tumor almost filling right lower lobe with sharply defined borders; center of somewhat unequal density; no evidence of metastasis.

borders but with a center of somewhat unequal density. Operation was advised but refused. The patient was therefore given a large number of deep roentgen-ray treatments each week over a period of several months and was sent to the country for a rest. During this time he gained 22 of the 38 pounds (10

of the 17.2 kg.) he had previously lost. He continued, however, to have dyspnea and upper abdominal distress. On his return to San Francisco this increased and he again began to lose weight.

October 18, he entered the Mount Zion Hospital under the care of Dr. Julius Sherman, and was seen by Dr. H. C. Moffitt and myself in consultation. The patient was a well developed man although he showed loss of weight. The fingers were markedly clubbed. He was very dyspneic on exertion and during conversa-

Fig. 2 (Case 1).—Oct. 7, 1924, pleural effusion on right side reaching about half way up the chest; tumor in right lower lobe totally obscured; heart shadow greatly enlarged; fluid in pericardial sac.

tion. He had an irritating cough with slight expectoration; but the sputum was not blood streaked, and there was no hemoptysis. There was dulness and flatness in the right chest with the exception of the upper third. Over this area there were no breath sounds or râles. The heart was irregular, the cardiac dul-

ness extending almost to the axilla. Sounds were distant. The blood pressure was 130 systolic, 70 diastolic. The abdomen was soft. The temperature usually was normal or subnormal. The Wassermann reaction was negative. Hemoglobin was 75 per cent. The red cells totaled 4,900,000; the white cells, 15,800, of which 80 per cent. were polymorphonuclears, 16 per cent. lymphocytes and 4 transitionals. The urine was light amber and acid; the specific gravity was 1.015; it contained a slight trace of albumin, a few hyaline casts, a few epithelium and pus

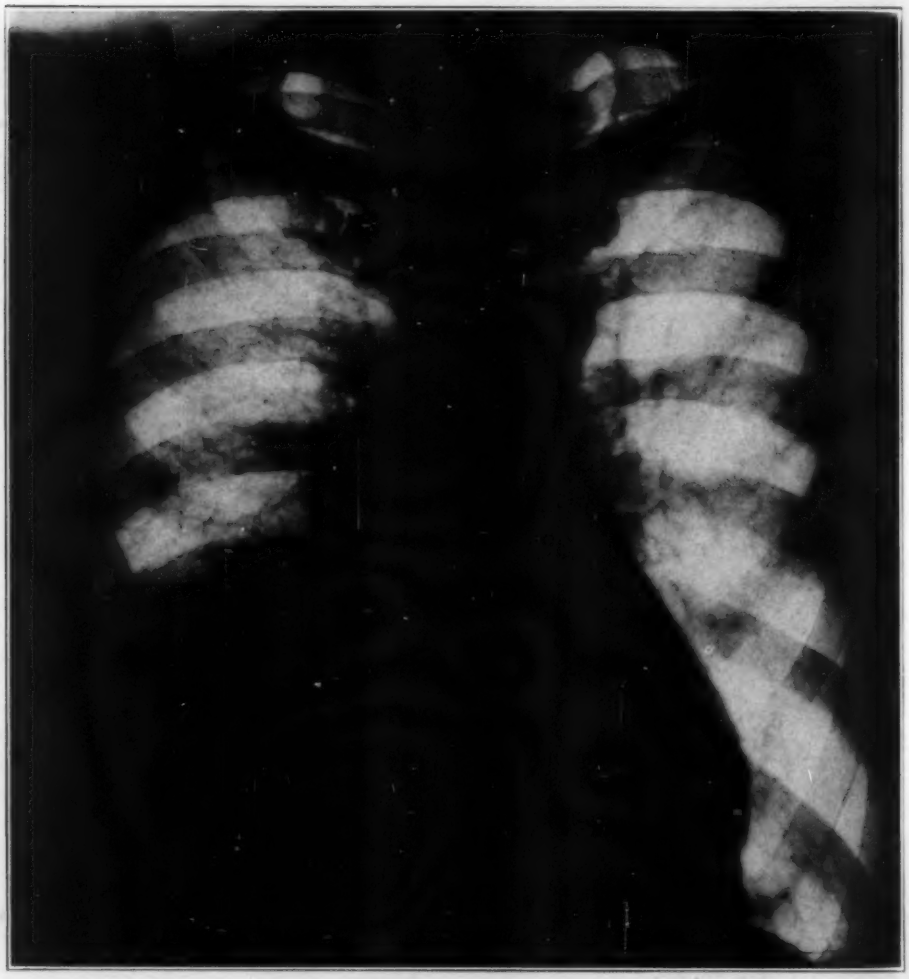

Fig. 3 (Case 1).—Nov. 3, 1924, tumor increased in size; interlobular septum well marked.

cells and bacteria. The stools were positive for occult blood. No tuberculosis bacilli were found in the sputum. A roentgenogram (Fig. 2, taken October 7) showed pleural effusion on the right side reaching about half way up the chest, totally obscuring the tumor in the right lower lobe. The heart shadow also was greatly enlarged, showing fluid in the pericardial sac. The patient was tapped

on two occasions, from 200 to 300 c.c. of fluid of specific gravity 1.015 being removed. This was turbid light amber. Red and white cells were found in the fluid, the latter in the proportion of 14 per cent. polymorphonuclears to 18 per cent. lymphocytes. The Rivalta test was slightly positive. No bacteria were found on smear or culture. Guinea-pig inoculations were negative for tuberculosis. On digitalis therapy the patient made general improvement but the pulse remained irregular.

There was some question as to the diagnosis of malignancy because of the absence of blood in the pleural fluid.

About this time aphonia due to paralysis of his left vocal cord developed.

After removal of the fluid in the chest, a roentgengram (Fig. 3, taken November 3) showed a round smooth shadow in the right lower lobe similar to that in the roentgenogram taken in June. There was also a small amount of fluid in the right side of the chest; the heart was enlarged but there was no evidence of pericardial effusion. The patient had improved much at this time, the effusion did not reappear and no evidence of metastasis was found in the other lung, in the bones, or in the mediastinum, careful search being made in order to explain the recurrent laryngeal paralysis; for these reasons we advised the patient and obtained his consent, to allow us to operate for removal of the tumor mass, which we considered a carcinoma of the lobar type with massive involvement of the right lower lobe.

Operation was performed November 13, under local procain anesthesia. A large U shaped incision was made in the lower part of the right side of the chest. Skin and muscle flaps were dissected upward and from 4 to 5 inches (10.1 to 12.7 cm.) of the sixth, seventh, eighth and ninth ribs were removed subperiosteally. The intercostal nerves were isolated and injected with 95 per cent. alcohol solution. The pleura was firmly adherent to the underlying lung and tumor. An incision was made through this somewhat thickened pleura, which was separated from the tumor. The tumor was hard, somewhat nodular, adherent to the diaphragm but not infiltrating it. It could be easily defined from the lung immediately above by its pearly white color and its hard nodular surface. In separating the tumor from the middle lobe it was broken into and a mass of necrotic materal from its center discharged itself into the wound. The outer rim of the tumor was quite friable. Masses about the size of both fists were cut away. The tumor was remarkably avascular and little serious bleeding was experienced. After we had removed most of the tumor mass the rest was thoroughly burned away with cautery; we even went at times into what seemed normal lung tissue. At one point posteriorly the tumor was very firm and fixed and seemed to be attached to the pleura and to the chest wall. This portion of the mass required considerable cauterization. A large cavity was left which was packed with petrolatum gauze. The pleura and skin edges were sutured in such a manner as to invert the skin into the cavity. We did this to prevent closure, as we expected to cauterize this cavity later. During the operation the patient was given 1,500 c.c. of Ringer's solution intramuscularly. The anesthesia was satisfactory and the patient complained of no pain during the removal of the tumor and its cauterization, except when we were working at the angle of the hilum with the diaphragm.

The patient returned to his bed in good condition except for an irregular pulse, which he had had previous to the operation. On two occasions about ten days apart, without either local or general anesthesia, the tumor in the lower lobe was again burned with the cautery iron. There was no pain and only slight reaction following these cauterizations.

Figure 4 was taken December 4, three weeks postoperative, and Figure 5 was taken March 25, 1925, four and one-half months after operation.

The following is a microscopic report of the tumor from Dr. G. Y. Rusk of the pathologic department of the University of California Medical School:

Microscopic examination was made from an unusual number of sections taken from various portions of the tissue submitted. Microscopic examination of about one third of these shows the tissue entirely necrotic, in places having lost all

Fig. 4 (Case 1).—Dec. 4, 1924, three weeks after operation; removal of tumor by actual cautery through a window made in chest by removal of sixth, seventh, eighth and ninth ribs.

structure and in other areas retaining an outline of tissue forms, coagulation necrosis as it were. Other portions of tissue showed intense fibrosis varying considerably in amount of cellularity and in evidences of old organization present. Accompanying these there were remnants of lung tissue showing an

intense interstitial pneumonia, with varying degrees of infiltration by lymphocytes and plasma cells. Endarteritis also was present to a marked degree. Alveolar epithelium covered these irregular inflammatory areas and in certain areas there was a distinct overgrowth of such epithelium extending into the denser fibrous tissue below. These abnormal epithelial cells were uniform in size, grew diffusely, showed no tendency to adenomatous formation, on the one hand, or cornification on the other. Many of the cells were seen undergoing mitotic divi-

Fig. 5 (Case 1).—March 26, 1925, four and one-half months after operation; collapse of chest wall and pleural thickening and possibly some tumor tissue remaining.

sion. While the connection between the alveoli epithelium and the new growth was marked in some places, in other sections small islands of the invading epithelium were seen deep in the tissues. The diagnosis was chronic interstitial pneumonia with marked necrosis, and epithelioma of the lung apparently arising from alveolar epithelium.

Not quite two months later, Jan. 8, 1925, the patient, who had left the hospital, showed a gain in weight; hemoglobin was increased to 80 per cent.; his color was improved, and he was walking around. There was a noticeable diminution in the clubbing of his fingers. His voice, however, remained as husky as before and there was still complete paralysis of the recurrent laryngeal nerve.

Roentgen-ray examination at this time showed no metastasis in other parts of the lung and a lateral view showed no evidence of carcinoma in the mediastinum. We felt that this paralysis might be due to the previous inflammatory trouble in the pleura and in the pericardium.

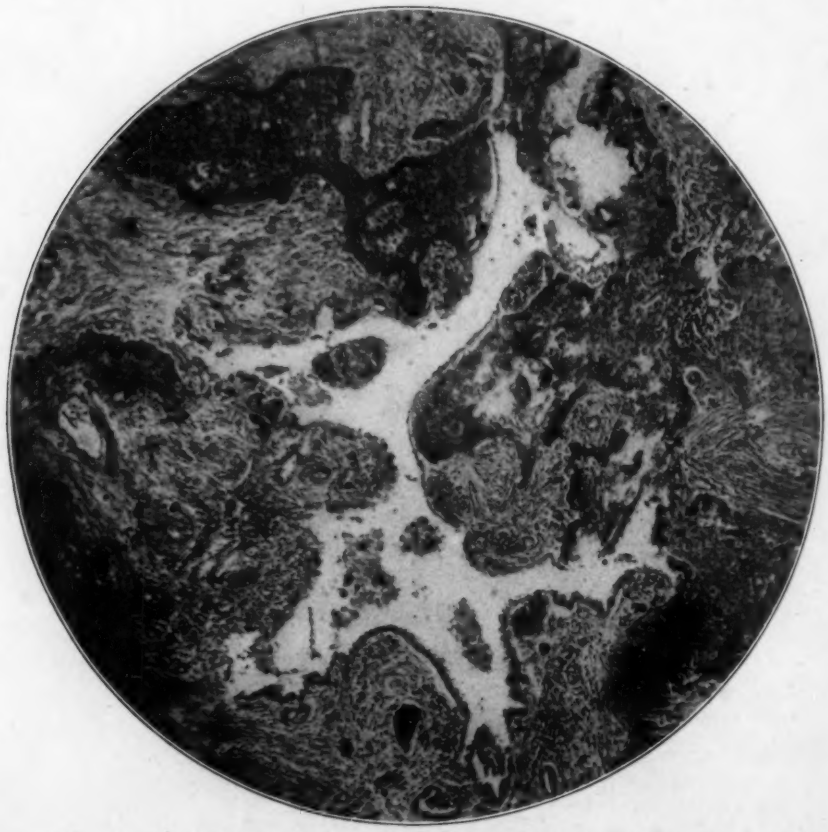

Fig. 6 (Case 1).—Epithelioma of lung, apparently arising from alveolar epithelium.

The patient was last seen about April 20. While still unable to work, he was around and about without any loss of weight, although at times he was kept awake with pain in the right side of the chest and in the neck. The chest had collapsed on the operated side, practically closing the large cavity. It was almost impossible to insert the finger into the cavity for palpation. Roentgen-ray examination showed a great amount of fibrosis in the surrounding lung. It was difficult to tell even by palpation if there had been a regrowth of the tumor. There

was still no evidence of metastasis. Figure 7, taken April 7, shows the appearance of the patient five months after operation.[1]

CASE 2.—E. P., aged 53, a Roumanian photographer and laborer, entered the San Francisco Hospital University of California medical service, July 8, 1924. He had been perfectly well until seven months before (January, 1924). At this time he had very sharp shooting pains in the lower spine radiating to both knees. There was no tenderness or swelling. The pain was increased by cold or windy weather. Since April the pain, which had been intermittent, became constant. For a month the patient had been confined to bed unable to stand because of this pain. There had been a slight morning cough with thick sputum for the past three months. There were no hemoptysis, no dyspnea and no shortness of breath.

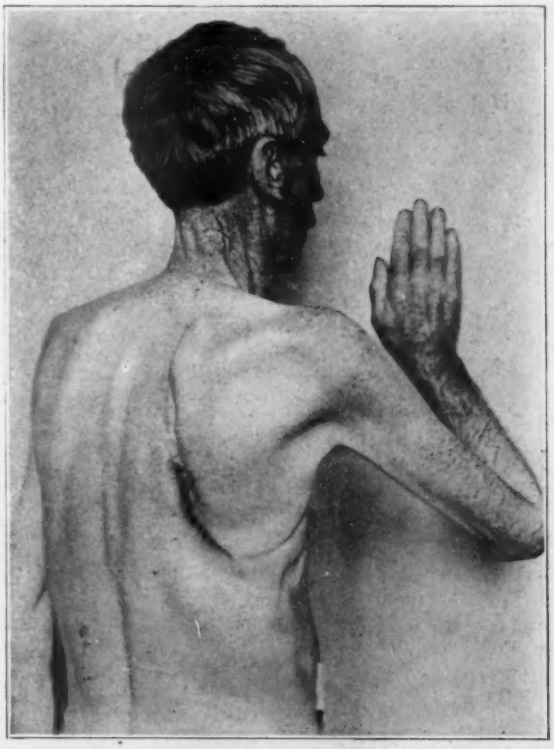

Fig. 7 (Case 1).—Patient five months after operation.

A slight swelling of the ankles had been present for the last few days. A sharp, burning pain in the right chest radiated to the right shoulder. These pains were intemittent. The appetite had been poor since the present illness. At infrequent intervals he had a heavy, burning pain in the epigastrium which seemed to be connected with the pain in the right side of the chest. There was paresthesia in both feet and legs, over the abdomen and chest and down both arms. The

1. Since this article was written this patient died, Aug. 18, 1925, eight months following operation. No postmortem was performed. The cause of death was largely circulatory although there was distinct evidence of recurrence in the chest at the site of operation.

patient described the feeling as that of an electric shock or of being soaked in gasoline and set afire.

Physical examination showed a fairly well developed and nourished man. The chest was barrel shaped and moved en masse on respiration. The breathing was entirely abnormal in type. Supraclavicular and infraclavicular fossae were quite well marked. The vocal fremitus was normal; the percussion note was resonant throughout. The breath sounds were bronchial at the right top, particularly to the

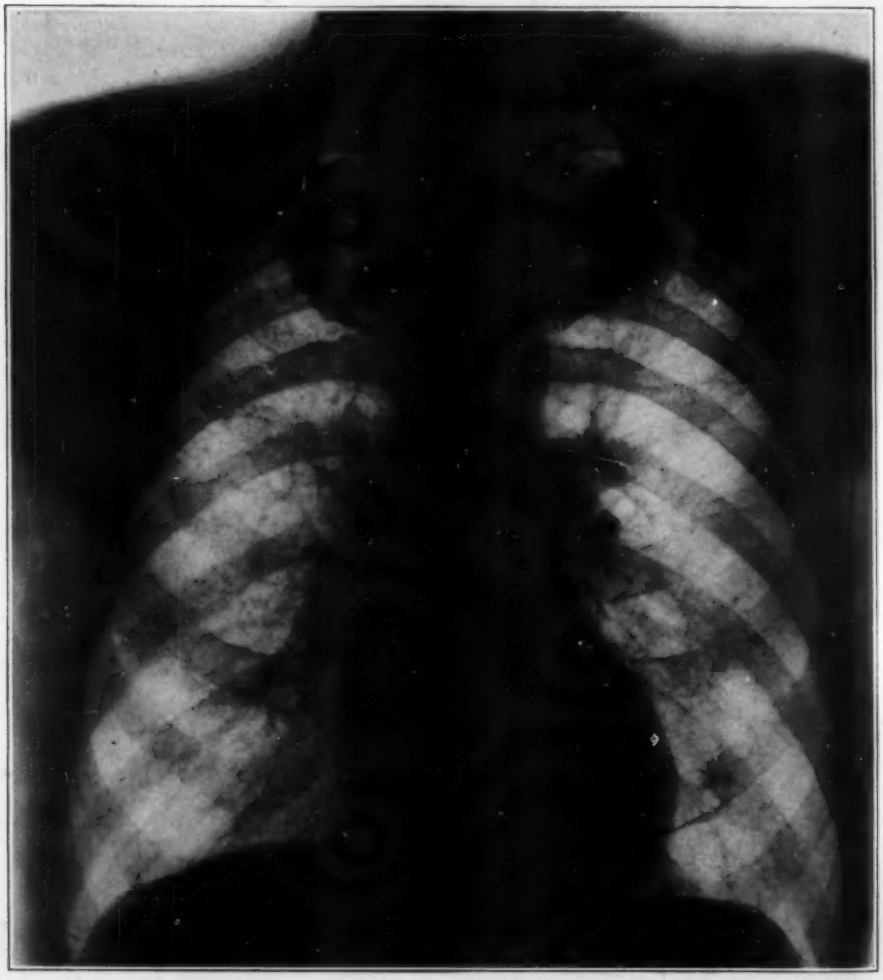

Fig. 8 (Case 2).—July 12, 1924, small circular tumor in upper left lobe just below clavicle; faint streaming lines to root of lung.

right of the first and second dorsal spines. At the right base expiration was prolonged and there were many râles, chiefly medium moist. The area of cardiac dulness in the heart was practically obliterated by emphysematous lung. The heart sounds were distant, being scarcely audible; the apex impulse was neither seen nor felt. The systolic blood pressure was 100, the diastolic 60. The pulse rate was

76. The radial pulses were equal, synchronous, of good quality and well sustained. The left testis was atrophic and soft, the right was negative. The skin of the extremities was dry and scaly. Marked clubbing of both fingers and toes had been present for two months. There was marked tenderness over the right thigh, leg and foot, over the lateral and the posterior surfaces of the left thigh, and over the entire left leg and foot. There was some swelling and extreme tenderness of both knees, a reddened area was seen over both metatarsal areas, more marked

Fig. 9 (Case 2).—Aug. 15, 1925, circular area of density as on previous plate but shadow extending to root of lung better defined; frequently mistaken for inflammatory process.

on the right. The joints were distinctly warmer than normal. Marked tenderness was present over the sciatic and the radial nerves. Both ankles were edematous. The cremasteric reflex was absent. Rectal examination revealed normal sphincter tone; there were no hemorrhoids and no masses were felt. The prostate was normal in size, shape and consistency.

Urinalysis was repeatedly negative except for an occasional pus cell. The blood count was: hemoglobin, 80 per cent.; red blood cells, 3,750,000; white cells, from 7,000 to 11,000. The blood Wassermann reaction was negative, and the spinal fluid Wassermann reaction was negative. The spinal fluid was clear, sparkling under increased pressure. There were no cells. The Ross-Jones reaction was negative, and the Pandy reaction was faintly positive. The gold curve was 0000000000. The blood uric acid, August 5, was 1.44 mg. per hundred cubic centimeters, and the blood sugar, August 15, was 125 mg. of dextrose per hundred cubic centimeters. There were no blood, pus, elastic tissue or tubercle bacilli in the sputum.

A roentgenogram of the chest (Fig. 8) taken July 12 showed thickening over both apexes. The hilums were extensive, the right being elongated downward toward the base. The bronchial tree markings in both lung fields were overprominent and extended very widely, especially in the left apex. In the left intra-

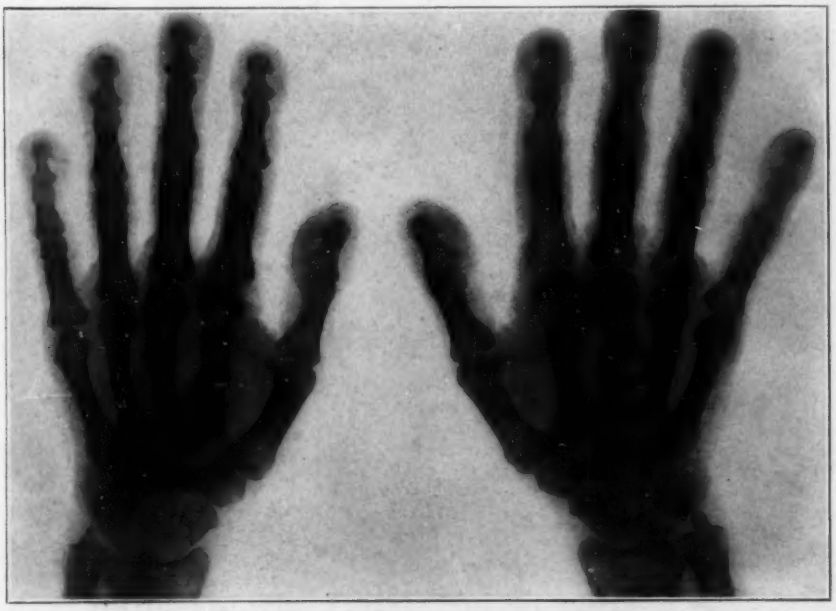

Fig. 10 (Case 2).—Secondary hypertrophic osteo-arthropathy; marked clubbing of fingers with spurring of the terminal phalanges.

clavicular region there was circular shadow of solid, smooth density about 1 inch (2.5 cm.) in diameter. This shadow was interpreted as a possible malignancy; a calcified tuberculous condition also was considered.

A roentgenogram of the chest (Fig. 9) taken August 15, about a month later, showed the same circular area of density seen in the infraclavicular region, but with it there was a strand of bronchial tree markings extending upward from the left lung root to this area of density. This was interpreted as an inflammatory process.

About the same time roentgenograms were taken of the extremities. These showed secondary pulmonary hypertrophic osteo-arthropathy involving the tibia and the fibula and the ulna and the radius on both sides; also periosteal changes of the right fifth metatarsal, the left fifth metatarsal and the right proximal

phalanx of the fifth finger. The clubbing of the fingers and toes showed very well in the roentgenogram. There was marked spurring of the terminal phalanges, which were somewhat mushroom in shape.

It is interesting to note that this patient remained on the medical side—a very active and inquiring medical service—for a period of six months before surgical consultation was called, even though the staff were aware of our interest in lung conditions. The diagnosis of this patient's condition varied from time to time and was delayed somewhat because of the indefinite roentgen-ray reports. Malignancy of the lung was suggested on several occasions because of the small well defined mass in the upper lobe which was thought at one time to be a calcified turberculosis cavity or a filled cavity, or perhaps a secondary malignant metastasis from an unknown source. The second roentgenogram, made August 27, which shows a streamy line extending from the tumor to the hilum even more marked than on

Fig. 11 (Case 2).—Secondary hypertrophic osteo-arthropathy; similar changes to those in hand but not so marked.

the first plate led to an interpretation of an inflammatory process. This apparently is a mistake frequently made but is quite characteristic of malignancy. The marked osteo-arthropathy of the extremities was diagnosed by roentgen ray, but the very minor involvement of the lung diverted the diagnosis from cancer as a probable cause and he was treated for arthritis.

Jan. 9, 1925, a roentgenogram (Fig. 14) of the left side of the upper part of the chest showed a massive density over a much larger area than before. The margins were fairly smooth and very definite. The roentgen-ray diagnosis then made was malignancy of the lung, probably sarcoma. The surgical staff was called in consultation, January 16; when they had reviewed the history and the roentgenograms, they came to the conclusion that this was a case of primary

carcinoma of the lung, the carcinoma lying posteriorly and extending from the second rib behind to beyond the fifth rib.

At this time the patient showed considerable emaciation, was very irritable and sick looking, taciturn and uninterested in what was going on. The pain in the legs and feet had markedly increased; the patient required opiates day and night and the slightest touch of the bed clothes caused him to exclaim. We appreciated that this man was not a good subject for operation, both on account of his physical condition and the rapid extension that the carcinoma had made

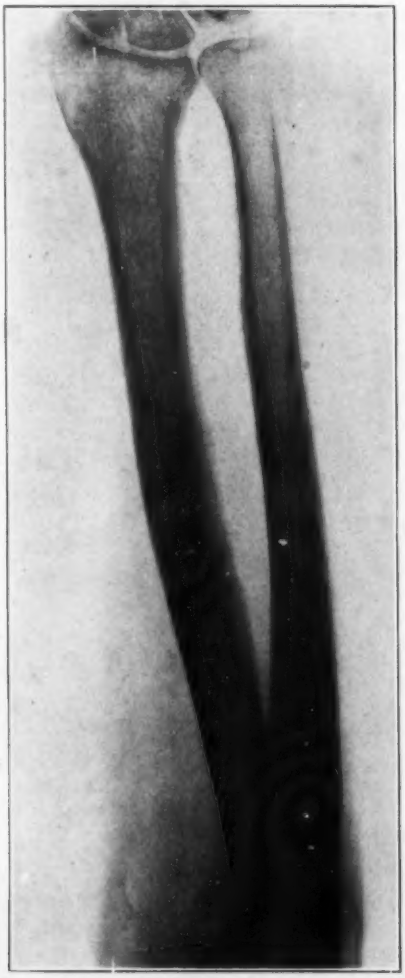

Fig. 12 (Case 2).—Secondary hypertrophic osteo-arthropathy showing periosteal proliferation along radius and ulna.

from the apex down to the hilum during the previous six months. While the downward course of this patient was rapid no other metastases were found; the disease was still localized in the upper left lobe. The patient was anxious to have something done to relieve his excruciating pain and we felt justified in making some attempt at the removal of this tumor if possible by cauterization.

An operation was performed under local anesthesia, January 23. A long incision was made between the scapula and the erector spinal group of muscles, extending from the first rib downward to the eighth, somewhat encircling the end of the scapula. The scapula was thrown forward and the second, third, fourth and fifth ribs were removed from the posterior angle forward under the scapula from 3 to 5 inches (7.6 to 12.7 cm.). On examination we found that the pleura

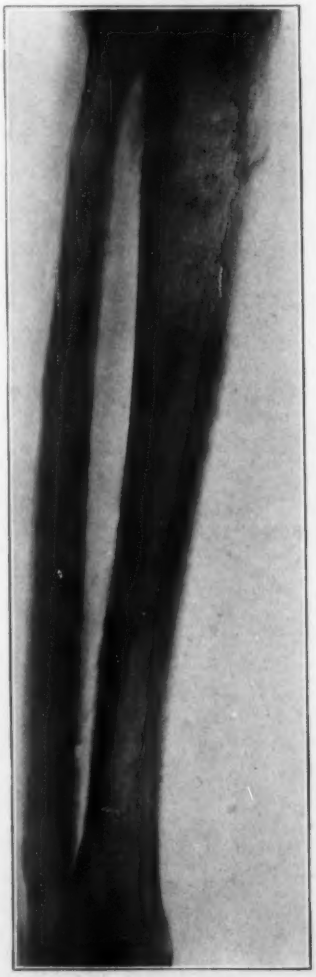

Fig. 13 (Case 2).—Secondary hypertrophic osteo-arthropathy showing periosteal proliferation along fibula and tibia.

was not adherent. The lung could be seen gliding under it with each respiration. Through the thin pleura the tumor mass could be both seen and felt projecting somewhat beyond the lung tissue; it was very dense. Its outlines were well defined from the rest of the lung. The pleura was not opened. Its outer surface was painted with dilute iodin and a pack of iodoform gauze was laid on it to bring about adhesions. There was very slight reaction from the operation, either in

temperature, pulse or respiration. There was considerable relief of pain in the arms and legs and he could move about freely, something he had been unable to do before. Why this should have occurred is difficult to explain.

January 30, one week later, the second stage of the operation was performed without anesthesia. The parietal and visceral pleura were well adhered over the entire operated area. The mass in the lung was cut into and a liberal piece of the tumor removed with a cautery knife for examination. The rest of the tumor was well cauterized with a hot soldering iron.

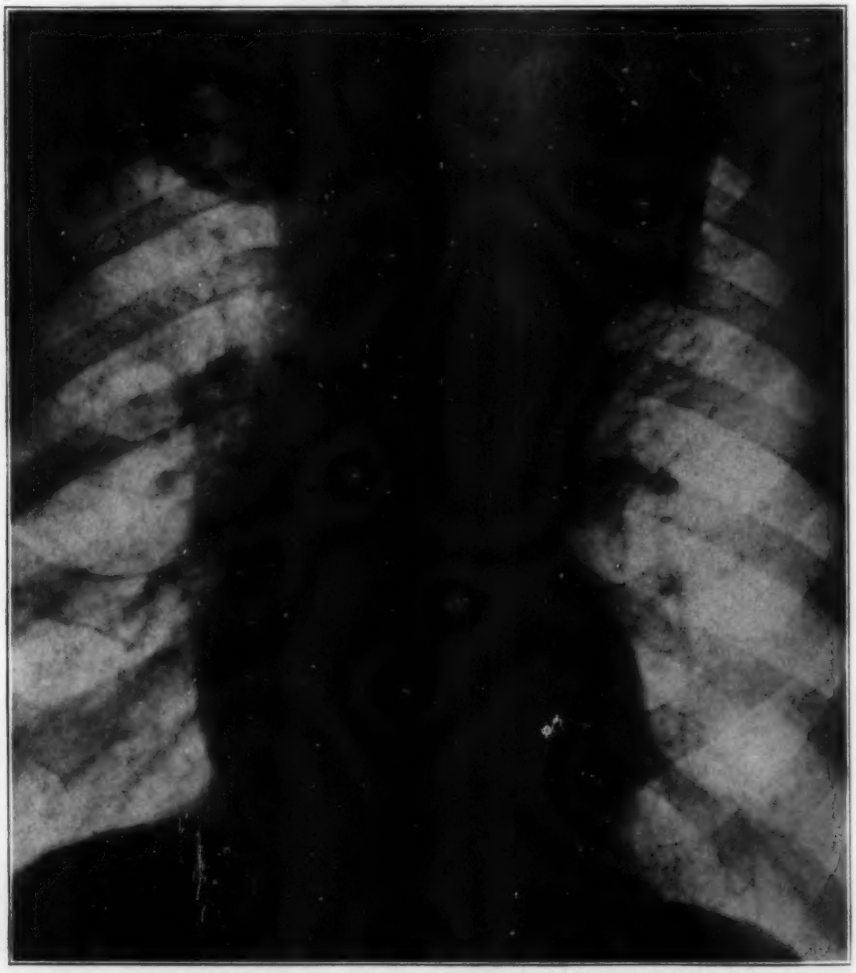

Fig. 14 (Case 2).—Jan. 9, 1925, before operation, showing extensive advance and a massive increase in tumor growth extending from first to fourth rib.

Unfortunately, we attempted to do too much cauterization at one sitting. The soldering iron passed beyond our line of adhesions on to the anterior surface of the lung; there was a sudden rush of air into the pleural cavity with collapse of the apex and other parts of the lung although the posterior part still remained

adherent. We packed the opening with petrolatum gauze but were unable to stitch the edge of the lung to the parietal pleura. As a result of this opening into the free cavity in front, which should have been avoided, an empyema occurred as we had anticipated.

In spite of what seemed adequate drainage the patient's condition was so low that he died ten days after operation.

Fig. 15 (Case 2).—Cross section of left lung: *A*, tumor in upper lobe; *B*, nodule involving a large bronchus and almost filling its lumen.

Following the second operation, the pain in the patient's legs improved almost completely. His feet and legs and joints could be pressed on and moved with impunity. If he had lived and had been relieved only of these pains the operation would have been justifiable. I believe that we might have removed most of this tumor by repeated cauterizations and perhaps have prolonged his life had not this unnecessary error in technic occurred. His chances also would have been greatly

improved had he been operated on when the tumor was small, in July, 1924, on entrance to the hospital.

The anatomic and microscopic report of the necropsy made by Dr. G. Y. Rusk of the pathologic department of the University of California Medical School was as follows: There were primary adenocarcinoma of the left upper lobe, with linear extension to the hilum lymph nodes; metastases to the pleural surfaces of the right upper and lower lobes; a patent thoracotomy wound in the posterior aspect of the left side of the chest, with about one third of the left upper lobe removed; an interstitial inflammatory reaction, with extensive necrosis about the site of cauterization; empyema of the left side of the lower part of the chest; 122 c.c. of

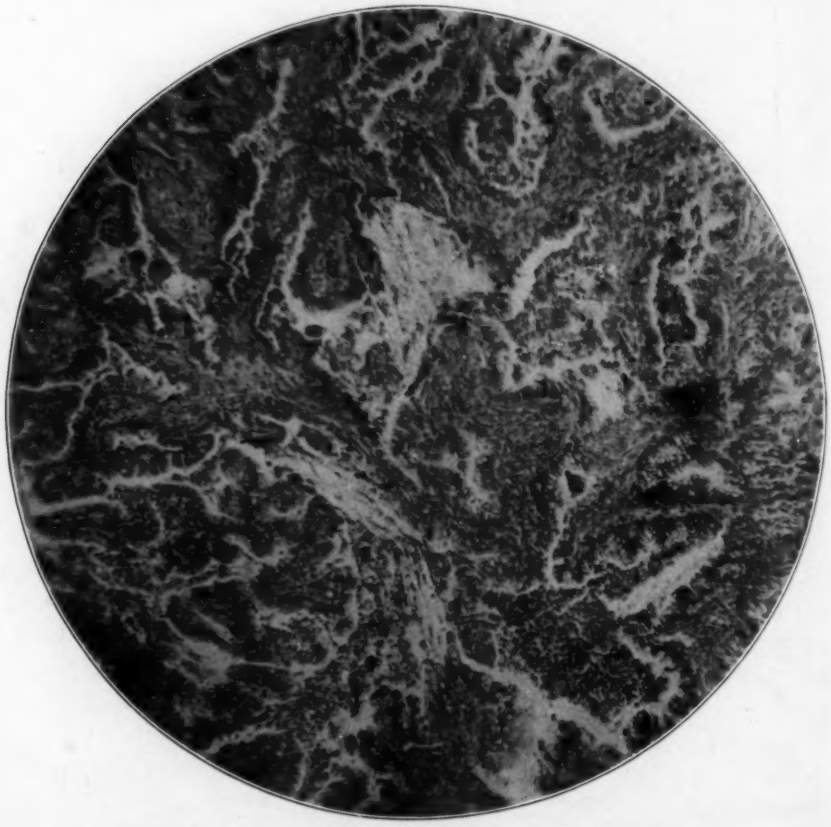

Fig. 16 (Case 2).—Microscopic section of lung tumor.

sanguinopurulent fluid walled off by fibrous and fibrinous adhesions; compression, bronchitis, interstitial pneumonia and bronchopneumonia and fibrous and fibrinous pleuritis of the left lower lobe; acute splenic tumor with hyaline deposits in the malpighian corpuscles; marked pulmonary osteo-arthropathy of the fingers and toes; fibrous peritoneal adhesions; pleural transudate, 150 c.c. of clear fluid on the right side of the chest; gastroptosis; passive congestion and cloudy swelling of the viscera.

Figure 15 shows a cross section of the lung containing the carcinomatous mass in the upper lobe. The cauterized area can be seen somewhat contracted owing

to fixing. The area *A* shows the part of the tumor still remaining which would have been cauterized from time to time had the patient lived. The point *B* designates a small circumscribed tumor practically filling a large bronchus at the root of the lung. It is interesting to surmise whether or not this bronchial mass was the original site of the carcinoma or whether it had its origin in the apex of the lung, where it is clearly shown in the early plates. I am inclined to believe that the primary site was at the apex and not at the bronchus. A bronchial tumor usually gives symptoms of which the patient did not complain in the early stages, such as cough and dyspnea. There was no atelectasis of the lung nor was there any bronchiectasis or other forms of infection so commonly present when the tumor primarily begins in a bronchus.

Figure 16 is a microscopic picture of the tumor in this case. Dr. G. Y. Rusk made the following report:

Microscopic examinations of sections from the lung tumor showed it to consist of abnormal epithelial cells, massed for the most part in alveoli of various sizes; between the alveoli was scanty stroma. The epithelial cells were of high columnar type, from one to many layers thick. A lumen formation was frequently observed. In other areas the growth took on a papillary adenocarcinomatous appearance. The tumor cells were relatively large; at times the protoplasm stained diffusely, but not infrequently the cells showed marked vacuolization, especially in their distal portion. The nuclei were large and clear staining, and mitotic figures were quite frequent. Areas of necrosis were not infrequent in the tumor and in these spaces occurred where apparently fat cystals or cholesterol had dissolved out. The diagnosis was papillary adenocarcinoma of the lung.

Many excellent papers have been written from various clinics in the last few years emphasizing the incidence, pathology, symptoms and diagnosis of primary carcinoma of the lung. Eloesser from Stanford University School of Medicine reported twenty-five cases before this society last year. Rusk and Randolph from the pathologic department of the University of California Medical School reported twenty-five cases at the last California state meeting. All of these cases occurred during the last eight years; twenty-three of them were examined postmortem. Dr. Rusk has allowed me to quote freely from his report, and I have added these cases to the statistical studies in this article.

The rest of this article will therefore mainly concern itself with the points in primary carcinoma of the lung that should be emphasized in order to reach an early diagnosis and thereby possible relief by surgery.

INCIDENCE

The incidence of primary carcinoma of the lung seems to be increasing. Numerous clinics report in their later statistics a much greater frequency. This can be well shown from necropsy reports. We have compiled the following data: From 1872 to 1898, a period of twenty-six years, 382,671 necropsies showed 159 cases of primary carcinoma, or 0.04 per cent. From 1898 to 1916, a period of eight years, 192,271 necropsies showed 488 cases, or 0.24 per cent., six times as great

a number. From 1916 to 1924, a period of eight years, 33,308 necropsies showed seventy-one cases, or 0.21 per cent. From 1916 to 1924 is the period after the influenza epidemic, but the incidence is no greater than during the previous eight years. This increase may be due to many other factors however than an actual increase in the disease: more careful search, especially in tuberculous cases, the use of the roentgen ray, which draws attention to unusual conditions in the lung, and especially the more infrequent diagnosis of sarcoma of the lung and the placing of these cases in the carcinoma group. Ewing considers that in the ninety cases of sarcoma of the lung reported by Adler the minority only belong to this group, so that we now consider primary sarcoma of the lung a much rarer disease than previously. The twenty-five cases of Rusk and Randolph at the University of California Medical School show 1.36 per cent. of all necropsies.

This disease occurs much more frequently in men than in women, almost in the relation of 75 per cent. in males to 25 per cent. in females. The age incidence is given in Table 1.

TABLE 1.—*Age Incidence*

	Cases	
From 1 to 20 years	7	
From 20 to 40 years	60	
From 40 to 60 years	361	505
From 60 to 80 years	144	
From 80 to 100 years	4	
Total	576	

It will be seen, therefore, that although cases occur at the extremes of age most of them will be found after 40 years, 90 per cent. occurring after 40 and between 40 and 80 years.

Chronic irritation and chronic inflammation are considered by most authors as predisposing causes to primary carcinoma of the lung. While previously tuberculosis and carcinoma were considered antagonistic owing to the dictum of Rokitansky, later works seem rather to show that they are frequently coexisting; Ewing believes that the chief etiologic factor of carcinoma of the lung is tuberculosis. Many authors also point out the possibility of the etiologic relation of influenza to this disease. The presence of postinfluenzal metaplasia of the cells lining the bronchi lately reported by pathologists gives a starting point no doubt for many of the epidermoid or squamous celled carcinoma arising in the lung. Chronic irritation as a cause seems further to be emphasized by the fact that it is so predominant in the male sex.

From the surgical standpoint it is important to consider carefully the duration of symptoms of carcinoma of the lung because herein lies an opportunity for earlier diagnosis and increased operability. Unfor-

tunately from this point of view carcinoma of the lung might well be compared to carcinoma of the stomach. Numerous histories show that while a patient dates the onset of the disease from some striking symptom, failure in health and strength dates back a year or more previously, just as is the case in carcinoma of the stomach. Frequently patients pass from clinic to clinic over a long period of time before the true nature of the disability is discovered. For this reason in the statistics we have gathered the duration of symptoms is much less than is actually the case. In a study of 626 cases including those in Adler's statistics, we find the duration of symptoms as given in Table 2.

Comparing the pathologic picture and histologic types of the disease with the symptoms brings us to a few definite conclusions. It would seem that squamous cell carcinoma has a slower and more chronic course and it will probably be found that they are the most operable of all types of carcinoma, especially when peripherally placed. All periph-

TABLE 2.—*Duration of Symptoms in Six Hundred and Twenty-six Cases, Including Those in Adler's Statistics*

	Cases		
From 0 to 3 months	71	133	223
From 3 to 6 months	62		
From 6 to 9 months	42	90	
From 9 to 12 months	48		
From 12 to 15 months	18		
From 15 to 18 months	18		
From 18 to 24 months	18		
From 24 months to 3 years	8		
Three years or more	12		

Duration in 80 per cent., one year or less; in 50 per cent., six months or less.

eral tumors, indeed, arising from the alveoli and composed of cuboidal or round cells, are also, on account of their location, favorable for operation.

SYMPTOMS

The symptoms of this disease are extremely variable and it is because of this fact that the possibility of carcinoma is so frequently overlooked. In our statistical study of the symptomatology of this disease we have covered 626 case reports, 252 of which have been reported since Adler's monograph. The most striking symptoms are the following:

Cough.—Cough is usually the first symptom to appear and is dry and irritating at first, later productive of mucus and sometimes streaked with blood. In some cases the cough is hardly noticeable and not troublesome until late in the disease. On the other hand, it may be productive and annoying. This will depend largely on the location of the tumor and its relation to the bronchus. In the second case that I report the diagnosis was overlooked for a long period of time. There was a

slight nonproductive cough but it was not at all dominant and disappeared for days at a time. Hemoptysis of blood streaked sputum in the same way may be variable but when it is present is suggestive. In the 626 cases that we reviewed cough was present only in 65 per cent.

Sputum.—The production of sputum occurs relatively late in the disease, the cases with bronchial obstruction being more productive than others. Sooner or later the sputum will become blood streaked and the patient will have hemorrhages of varying amounts. In the papillary types this may come on quite early, also in those cases in which there is considerable bronchial destruction and infiltration. The sputum was blood streaked or the patient had a hemoptysis in at least 40 per cent. of the cases compiled. Sputum was present in about 75 per cent. of the

TABLE 3.—*Location and Origin of Tumors*

	Adler	Cases Compiled	Total
Location of Tumors:			
Right side	188	95	283
Left side	157	89	246
Both sides	18	8	26
Not stated	8	60	68
Doubtful	3	0	3
	374	252	626
Lobe Distribution of Tumors:			
Right upper lobe			24
Right middle lobe			5
Right lower lobe			8
Left upper lobe			17
Left lower lobe			11
Right hilum			9
Left hilum			7

	Adler	Cases Compiled	Total
Origin:			
Bronchial origin	44	85	129
Alveolar structure (of alveolar origin?)	84	8 (5 right, 3 left)	
Probable bronchial origin	11		
Right upper bronchus	..	8	
Right middle bronchus	..	3	
Right lower bronchus	..	9	
Right main bronchus	..	28	
Left upper bronchus	..	9	
Left main bronchus	..	26	

cases and reported absent in twenty-nine cases. As complicating infections, necrosis and bronchiectatic cavities occur; the sputum may of course become profuse and foul but these are not early symptoms of the disease. The "currant jelly" sputum which Adler and others have thought pathognomonic is rarely mentioned in the later case reports and is probably not of any particular diagnostic value. The presence of tubercle bacilli in the sputum should not preclude the possibility of lung tumor, especially in a patient past middle life (40 years) and who has been in fairly good health previous to the onset. This also holds good even in a person who might well be considered tuberculous as the cases we have reviewed show that tuberculosis was present in about 10 per cent. The sputum should be examined thoroughly as several cases of carcinoma of the lung have been diagnosed by the finding of

tumor shreds and cells in it. These may appear rather early in the case, especially when there are intrabronchial growths.

Lenhartz, Osler and Adler speak of certain types of cells present in carcinomatous sputums which are pathognomonic. They are supposed to occur in large numbers and should therefore be easily found. Very little, however, has been mentioned of them lately in the literature. They are large spherical cells filled with a multitude of fatty granules and associated with an abundance of epithelial cells that are strangely deformed and possess clublike or taillike projections (Lenhartz).

Pain.—Pain often is an early symptom. It might be present entirely alone without any other pulmonary symptom and in these cases it often is due to metastatic causes. It may, however, be due to implantation on the pleura and when it occurs it is quite distressing. It seldom is relieved by strapping and always calls for opiates. Pain occurred in at least 60 per cent. of the cases. The pain usually is of the pleuritic character, sharp and lancinating. It may radiate to the shoulder when the diaphragm is involved or to the epigastrium or it may on the contrary be dull and constant, or merely a sense of discomfort and oppression in the chest.

Dyspnea.—Dyspnea, while it may at times be an early symptom, as a rule occurs later than the others. In cases of lobar proliferation without bronchial involvement or in cases with miliary metastases it may occur first. In most cases, however, it follows other symptoms and is generally due to occlusion of one of the larger bronchi by the tumor. An intrabronchial tumor in a large bronchus may cause considerable dyspnea without any discernible infiltration or lung shadow. As a rule, however, the amount of dyspnea is proportional to the amount of lung tissue involved. On the other hand, it often is surprising to find these large lobar tumors with little evidence of any pulmonary difficulty. Dyspnea occurred at some time or other in 50 per cent. of the cases. In many of the cases, however, it was due to varying amounts of effusion in the chest, which should always be looked for carefully.

Loss of Weight.—Loss of weight may in some cases be the only complaint of the patient and this loss of weight and strength may occur over a long period of time before he consults a physician. Frequently the patient will show some fever, but a physical examination of the chest will be negative, as will be all respiratory symptoms. A roentgen-ray examination in these cases would show the presence of mediastinal or pulmonary growth. As a rule loss of weight and cachexia occur comparatively late. There are, however, a number of cases that show gain in weight during the course of the disease. At times this may be due to the growth of enormous metastases, especially in the liver. Loss of weight or cachexia occurs in about 35 per cent. of the case histories.

The progress of the disease may of course be so rapid that there is insufficient time for this symptom to be noted.

Fever.—The presence of fever in many of these cases was noted in more than 45 per cent., but in many it was due to secondary infections or coincident conditions, such as tuberculosis, bronchitis, chronic pneumonitis and other complications. There seems, however, to be a tendency for a slight degree of fever to occur in uncomplicated cases of carcinoma of the lung.

Pressure Symptoms.—These as a rule occur late except where the initial focus is so located as to cause pressure or where it may be due to an early metastasis. Much of the early cough is due to pressure and irritation on the main bronchus or on the nerve fibers. Recurrent laryngeal paralysis occurred in nineteen cases. It was rather a late symptom in most instances and occurred in cases in which there was considerable mediastinal involvement or infiltration. In fifteen of the cases the paralysis was on the same side as the tumor. In one case it was on both sides owing to an encircling of the esophagus by the tumor infiltrations. In my first case there was laryngeal paralysis on the left side, although the tumor removed was on the right side, and while this tumor was probably due to metastasis to the bronchial glands numerous roentgen-ray examinations have failed to show, in lateral or oblique views of the chest, any evidence to cause such pressure.

Twenty-three patients had "rheumatic symptoms," bone and joint pains. Clubbing of the fingers was reported in only twenty cases, but its incidence was probably much higher.

Osteo-arthropathy.—Osteo-arthropathy (Marie's) was reported in only four cases. It probably has an incidence higher than this, for it is a condition the early stages of which often are overlooked. Some of the "rheumatic" complaints were probably on an osteo-arthropathy basis. A word should be said concerning this interesting disease, or we should say symptom, since it always occurs secondarily as a result of many morbid processes, most frequently, however, following pulmonary disease. The underlying cause of the proliferative changes that occur in the periosteum and soft tissues is still unknown. The toxic theory is the one most often advanced. Braun reports three cases of Marie's disease in which he demonstrated definite changes in the cellular constituents of the hypophysis. One case of cancer of the lung reported by Locke in 1915 showed a marked degree of osteo-arthropathy. At postmortem, in addition to a primary carcinoma of the lung, a marked hyperplasia of the hypophysis was found. These facts, together with the

close association of the changes in the disease to those of acromegaly, should direct our attention to the pituitary gland as the source of this phenomena. We would also direct attention to the fact that metastasis from primary lung carcinoma occurs in the suprarenal in 14 per cent. of cases. May not the pituitary also be subject to this predilection? We would suggest, therefore, that both by metastasis in lung carcinoma and by toxic effects on the pituitary gland changes may be brought about that lead to osteo-arthropathy. In the future, therefore, we would urge a more careful examination, both macroscopic and microscopic, of this gland at postmortem. Unfortunately, this was not done in the case reported by us.

Effusion.—Effusion occurs in a high percentage of cases. It was present fairly early in about 15 per cent. of the cases and occurred at some time in 45 per cent. For the most part it is a later manifestation. In cases in which there is an extensive involvement of lung and pleura it is hemorrhagic in character. The presence of effusion in cases without previous history of pulmonary condition should put the clinician on guard for a possible malignancy. Fluid should be removed both for relief of the patient and for examination. If hemorrhagic in a patient past middle life, it would strongly indicate malignancy until malignancy was absolutely ruled out. These effusions are best examined by centrifugating and by embedding the sediment in paraffin and sectioning. Several cases have been diagnosed by this procedure.

Bronchiectasis.—The presence of bronchiectasis is probably a secondary complication to lung carcinomas, especially those involving the bronchi and causing partial obstruction. The presence of this condition in a patient should therefore excite our curiosity as to its cause.

Tuberculosis.—From our statistics we find the occurrence of malignancy in fifty-three cases of tuberculosis. This should lead to a more careful examination of tuberculous necropsies for the presence of coincident malignancy. Ash in 1920 found seven cases of primary lung malignancy in 551 necropsies at a tuberculosis institution.

Metastases.—Metastases occurred in 85 per cent. of the cases. Many of the initial symptoms were due to metastatic involvement. These occur relatively early and may be the condition that brings the patient to the doctor. A great many of the clinical diagnoses were made on metastatic involvement, mainly cerebral or bone involvement. The brain was involved in 12 per cent. of the cases; the liver in 30 per cent., and the kidneys in 20 per cent. Two striking features in the occurrence of metastases are that the heart was involved in 21 per cent. of the cases and the suprarenals in 14 per cent. in a study of 626 case reports.

Diagnosis.—In the diagnosis of primary carcinoma of the lung the clinical history is of the utmost importance. This combined with the physical examination and the use of such laboratory aids as the examination of the effusion and the sputum and the roentgen-ray and bronchoscopic examination must all be correlated in order to arrive at an early diagnosis. Fishberg points out that there are two symptoms in carcinoma which are rarely seen in early tuberculosis, pain in the chest and dyspnea. He says:

> Nearly all patients with malignant growths in the chest cough and expectorate sputum. It is important to think of a pulmonary neoplasm when a patient in the carcinoma age showing no symptoms of cardiac, renal or arterial disease begins suddenly to cough and is short of breath.

Roentgenologic Diagnosis.—In the roentgenologic diagnosis we have to consider benign tumors, which are rare, generally clear cut in outline, and fail to increase in size on repeated examinations. Malignant tumors may be classified roentgenologically as (1) hilar, infiltrating and bronchial; (2) lobar, nodular and miliary, and (3) mixed.

Hilar tumors show (*a*) a massive shadow with clear cut border, or (*b*) a massive shadow with projections or infiltrations into the lung field. These cases are usually not diagnosed by the roentgen ray early. Repeated observations are necessary to watch the tumor's method of growth and there must also be a growth correlative with the other symptoms. Dependent on the stage of advancement, it may infiltrate the entire lobe and simulate the lobar type, but it generally lacks the sharp outline characteristic of lobar carcinoma. It usually is less dense and has an infiltrating border. Symptoms usually occur earlier than in other types, and it is sometimes diagnosed best and earliest by the bronchoscope. This type, too, may at times simulate chronic pneumonia because of the strands of tumor tissue infiltrating into the parenchyma.

The lobar types show (*a*) massive involvement of one or more lobes with or without metastatic shadows, or (*b*) multiple small nodules or miliary types. The lobar type usually involves the upper lobes. The symptoms usually are relatively latent, the tumor being extrabronchial. It often is limited to one lobe, with a sharp line of demarcation due to the septum. The apex of the lobe usually is clear in contrast to tuberculous shadows. Cavitation may simulate abscess but is usually obscured by the thick tumor growth. Metastases show a circular shadow in the same or the opposite lung, usually larger than those of miliary tuberculosis. Metastases may also be observed in the ribs and in the bony thorax. Bronchial obstruction by a small tumor may give atelectasis or bronchiectasis and the shadow of the small tumor may be obscured. Massive lobar tumors tend to displace the heart to one side

or the other, generally to the opposite side, while the left upper lobe tumors tend to push it down. Tumors of the upper lobe tend to displace the trachea to the opposite side. Occasionally the displacement is toward the affected side owing to the presence of infiltration. Five such cases have been found in our review of cases.

Bronchoscopy.—This is a most valuable adjuvant in diagnosis. It requires, of course, special training. Early bronchial tumors have been

TABLE 4.—*Cases Reviewed*

Author	Year	Number
Adler	1854–1912	374
Cottin	1900–1920	29*
Lavinovitch	1906–1915	61*
Peabody	1891	1
Hampelin	1891	1
Kidd	1892	1
Orgle	1893	1
Georgi	1899	1
Rusk	1916–1924	17
Eloesser	1915–1924	25
Carman	1914–1921	27
Barron	1912–1921	13
Ravenna	1909	1
Briese	1920	1
Gordon	1920	1
Bryan	1916–1921	4
Bridges	1922	4
Devar	1922	1
Fried	1915–1925	10
Friedman	1921	1
Gibson	1923	1
Haynes	1923	1
Leitz	1924	1
Locke	1915	1
Maclachlan	1921	4*
Packard	1917–1918	4
Pinchin	1922	1
Portis	1921	1
Rizer	1922	4
Scott and Formann	1916	4
Von Glehn	1923	7
Weller	1913	1
Davis	1908	2
Garbot	1906	1
Henerici	1912	1
McIntyre	1912	1
Packard	1905	1
Schrotler	1907	2
Stropein	1910	1
Watzuji	1904	5
Brunn	1924	2
University of California Hospital	1924	1
Moise	1921	5

* No histories.

diagnosed by means of the bronchoscope, even before they are demonstrable by roentgen ray. Points of pressure can be determined, cavities can be drained preoperatively, and biopsies immediately performed.

The difficulties in diagnosis may be gained from the fact that in the Fried series of ten cases from the Peter Bent Brigham Hospital only two were diagnosed antemortem. In Barron's fourteen cases from the University of Minnesota Medical School the three cases seen during the last year were diagnosed, but in only one of eleven previous cases

was a diagnosis made. Fishberg and Steinbach state that they have failed but once during the last five years to make a correct diagnosis in a series of thirty-three cases. It would appear, therefore, that the diagnosis is not so difficult when the clinician is conversant with the pathologic and clinical course of this disease and is on the alert for its suggestive symptoms.

CONCLUSIONS

1. Primary carcinoma of the lung is more prevalent than heretofore supposed.

2. The symptoms may be variable and diagnosis thereby delayed.

3. The roentgenologic findings are not uniform; they depend on the type of tumor, its location, mode of growth and such secondary processes as may arise in the lung.

4. Diagnosis will depend on a study of the growth in correlation with the symptoms.

5. More cases should and can be brought to surgery in the operable stage by early diagnosis or by exploratory operation.

6. The pituitary gland should be carefully examined at postmortem in cases of pulmonary osteo-arthropathy.

7. Surgery offers some hope to these hopeless sufferers either in the relief of pain, amelioration of symptoms, or perhaps in a cure.

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DISCUSSION ON THE PAPERS OF DRS. TOREK, MILLER AND BRUNN

DR. FREDERICK T. LORD, Boston: There have been sixty-five cases of actinomycosis at the Massachusetts General Hospital and of this number the lungs were primarily involved in nine (13.8 per cent.). The number of cases in which the lungs are primarily involved outnumber those with secondary pulmonary invasion. The aspiration into the deeper parts of the respiratory tract of organisms normally harbored in the mouth or tonsillar crypts is the probable explanation of the primary pulmonary form of the disease.

The diagnosis of primary pulmonary actinomycosis in its early stages is difficult and cases are likely to be mistaken for tuberculosis or malignant disease. Pleural pain is, however, likely to be a more prominent feature in actinomycosis and malignant disease than in tuberculosis, and perforation of the chest wall occurs in a large proportion of the cases of actinomycosis. Although at present a positive diagnosis cannot be made without finding typical club bearing actinomyces colonies in the sputum, it is important to become familiar with the roentgenographic appearances of the disease at an early stage. We have had one early case of primary pulmonary actinomycosis at the Massachusetts General Hospital.

As to the treatment of pulmonary actinomycosis, in our nine primary cases one patient recovered following operation. The patient, a man of 39, had had a cough with mucopurulent sputum for seven weeks. Actinomyces

colonies were found in the sputum. Roentgen-ray examination showed a triangular area of involvement with its apex at the left lung root and its base between the third and the sixth ribs at the axillary region. Drainage of an abscess through the region at the angle of the scapula was followed by recovery, and four years later there was no cough and the wound had closed.

Regarding the surgical treatment of malignant disease of the lung, the possibility of earlier diagnosis and advances in the technic of operation offer the hopeful prospect of successful removal in certain cases, as Lilienthal and Brunn have emphasized. As early recognition must to a large extent depend on the roentgen-ray findings we should so far as possible become familiar with them. In malignant disease of the lung root, suspected by roentgen-ray findings, bronchoscopic examination may establish the diagnosis and lobectomy may be performed for a growth occupying a bronchial branch leading to one lobe. Primary malignant disease developing in the pulmonary tissue inaccessible to the bronchoscope presents a more difficult diagnostic problem. When in this group, however, the clinical and roentgenographic findings suggest malignant disease it is not too much to expect that thoracic surgery will shortly advance to such a point that exploratory thoracotomy will be regarded as a justifiable procedure, and once the diagnosis is established the attempt to remove a new growth confined to one lobe would be justifiable even at considerable risk.

Dr. Howard Lilienthal, New York: A short time ago I presented a patient with actinomycosis of the jaw at a meeting of the New York Surgical Society. There had been several operations on the jaw by other surgeons, the diagnosis not having been clear. There was characteristic "lumpy jaw" when he came to me. A specimen was removed and the pathologist reported that it was one of actinomycosis. At the time there was a granulating wound which I treated by local applications of iodid of potassium. The wound healed but later began to soften. It then occurred to me that iodin ionization with potassium iodid might be efficacious. Dr. M. L. Rhein of New York kindly undertook this treatment for me and to my gratification all signs of the disease disappeared within a few weeks. The contrast with the former appearance of the patient was most impressive. I see no reason why a method similar to this might not be employed in actinomycosis of the lung. If roentgen ray is to be used Emil Beck's method of exposing the diseased place by the removal of as much of the chest wall as may be necessary should be employed. There is, however, danger of fatal roentgen-ray destruction of liver and spleen if the use of the roentgen-ray treatment is too massive by this technic.

Dr. Miller's presentation of cysts of the lung in otherwise unexplained spontaneous pneumothorax was most illuminating. It appears to me that in some of these cases it would not be necessary to wait for adult life before operating. In one of his cases especially, one lobe only was affected and its successful removal might have been possible. In early childhood the operation of lobectomy is not as dangerous as later in life.

Dr. Brunn's cases of cancer of the lung treated by operation are interesting and I congratulate him on his manner of dealing with this condition. One of the cases, however, was an extension from a bronchial cancer, a condition usually incurable.

There is no reason for the fear in the mind of most surgeons of a wide intercostal exploratory incision. This exploration *alone* should not be considered a dangerous operation, not as serious as an exploratory laparotomy. The patient may be out of bed within two or three days, sometimes even earlier.

Dr. Evarts A. Graham, St. Louis: Congenital cystic lung has been a most interesting proposition to me. I did not know these things existed before. I wonder if Dr. Miller knows anything about what relationship these might have to the so-called congenital bronchiectasis. I have felt in regard to congenital bronchiectasis that most of the cases probably represented early suppurations in infancy. I believe that suppuration of the lung in infancy occurs more commonly than we have any idea of. I think many times these suppurations are really straight aspiration phenomena, the result of an infant with a bottle in its mouth coughing and struggling and unable to get the bottle out. We have no idea about how often aspiration of milk and perhaps other things may result.

In cases of bronchiectasis which seemed to be of the so-called congenital type, on thorough questioning of the parents of the patient I have found that there were no symptoms that appeared at all until at least the second year of life. It would seem incomprehensible to me that such cases of bronchiectasis would really be congenital without having symptoms even during the first few months of life. But since I have heard Dr. Miller's presentation, I wonder if they might not possibly have some relationship with a congenital cystic formation.

I congratulate Dr. Brunn on his apparent partial success in one case. I wish to commend him most highly. When I advocated this procedure of radical cauterization of the lungs in chronic suppurations, I had in mind that it would be applicable to these primary malignancies of the lungs, perhaps also to actinomycosis, etc. Unfortunately I have not had an opportunity to try it because all the cases I have had have been so far advanced that there was nothing justifiable to do. They have been cases in which the pleura has been extensively involved and in most cases even the parietal pleura has been extensively involved so as to require too much cauterization.

Dr. Alexis Carrell, New York: I was especially interested in the paper of Dr. Brunn. It is quite extraordinary to see what has been accomplished in this field. I like the case of Dr. Torek. It is also striking to see that one can think of opening the thoracic cavity and making explorations.

Dr. Carl A. Hedblom, Madison, Wis.: I wanted to mention one patient with actinomycosis under my care. I have had three cases that were presumably, almost certainly primary in the lung, involved later on in the pleural cavity. One I dealt with as an ordinary empyema by operation; I only discovered actinomycosis later and then treated the patient with iodin solution irrigation. At the time of the last report, some eighteen months after he left, he was in fair condition and walking around; but the cavity, of course, had not healed.

The second case was one of frank suppuration; the patient was treated by aspiration and left before the treatment was completed.

The third, which I want to call special attention to, was a case with symptoms of bronchiectasis. We did a thoracoplasty. He was much improved in general condition and the sputum diminished 80 per cent. or more. About eighteen months after he had left the hospital, following the completion of the collapse of the pulmonary lung I was called to see him. There was a fluctuating mass under the scapula, and on aspirating and examining the pus actinomycotic organisms were found. We had been dealing with a case of actinomycosis of the lungs unrecognized at the time of the operation. The cough and sputum, by the way, followed an operation for appendicitis five years before.

I have nothing to add in the way of results following operation for carcinoma of the lung. All the cases I have seen have been advanced. One patient I operated on following a diagnosis of pulmonary abscess was found to have a localized carcinoma, the center of which had broken down with a secondary abscess resulting. He would have been a patient on whom one might have attempted a cautery extirpation, but he was in poor condition and we thought we would wait a few days to see if he would improve. He died within a week after the draining.

I wish to add my commendation on the work of Dr. Brunn. I would like to endorse Dr. Lilienthal's statement that exploration should be performed early when carcinoma is suspected.

Dr. Robert T. Miller, Jr., Baltimore: With reference to Dr. Lilienthal's suggestion that this condition apparently offers an occasional opportunity for successful surgical management, namely, excision of the altered portions of the lung, it is to be said that the disease in the vast majority of cases produces its clinical picture in very early life. Most of the reported cases have been in children one year or less in age. Radical thoracic surgery on so young a patient is as yet hardly feasible. Most of the reports have been pathologic rather than surgical. I have not encountered in the literature any clinical discussion designed with the purpose of grouping these cases together, although it would appear that they usually have a rather typical history which should at least suggest the diagnosis. It may be, however, that further study of the matter will prove my impression concerning the typical picture produced by the disease to be incorrect, and it is therefore to be hoped that such cases as are encountered will be reported in full. Certain of the individuals afflicted with this condition live to adult life; the reports of this particular group are more apt to emphasize the occurrence of acute pulmonary disease to which a congenital cystic lung is so liable. Dr. Graham suggests that congenital cystic changes in the lung may serve as the starting point for the development of bronchiectasis. This is an interesting thought, and quite possibly correct; the idea, however, can scarcely be put in more positive form than as a suggestion such as he has made, in view of the obscure state of our knowledge of the genesis of bronchiectasis in general.

BILATERAL AND UNILATERAL NONTUBERCULOUS SPONTANEOUS PNEUMOTHORAX

LEON THEODORE LEWALD, M.D.
Professor of Roentgenology, New York University and
Bellevue Hospital Medical College
NEW YORK

Whereas unilateral spontaneous pneumothorax is not infrequently encountered, a bilateral one is rarely encountered. However, one other case besides the one reported in this paper has been observed.* The case reported here was mentioned at a previous meeting of this society in a discussion of a paper by Graham, in 1923, relative to the experimental production of bilateral pneumothorax in dogs. It is remarkable that in these two human cases of bilateral pneumothorax, prompt recovery has resulted in spite of the collapse of both lungs (Fig. 1, A and B).

In spontaneous pneumothorax, either unilateral or bilateral, it is not safe to infer that complete expansion of one or both lungs will result. In two cases observed by me the lung failed to expand in each case. One case was observed for about a period of a year and the other case for a period of more than six years (Fig. 3, A and B).

On the other hand there usually is a rapid expansion of the lung and complete restoration of the chest cavity to a normal condition (Fig. 2, A and B). This can at times be hastened by attempts at increasing the intrapulmonary pressure by blowing air into a water bottle, or some similar procedure.

In inducing *artificial* pneumothorax, Fishberg [1] states that "spontaneous" pneumothorax may occur when the needle lacerates the visceral pleura, or when a superficial lesion or cavity of the lung breaks through after the pleural sheets are separated by the gas. According to Brauer and Spengler,[2] a spontaneous, or pneumogenous, pneumothorax may occur when the needle happens to strike an emphysematous bleb, and they mention a case in which necropsy confirmed this opinion. Wallgren [3] has met with two similar cases.

The following remarks by Terry [4] relative to one of the cases referred to me for roentgen-ray examination are of interest.

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*Miller, J. A.: Personal communication to the author, Jan. 14, 1925.

1. Fishberg: Pulmonary Tuberculosis, Philadelphia, Lea and Febiger, 1922, pp. 818-819.

2. Brauer and Spengler: Handb. d. Tuberkulose **3**:180, 1919.

3. Wallgren: Beitr. z. Klin. d. Tuberkulose **35**:319, 1916.

4. Terry, A. H., Jr.: Pneumothorax of Uncertain Etiology, J. A. M. A. **66**:1776 (June 3) 1916.

"Pneumothorax is said to be spontaneous or natural when there is no evident external or internal cause. There must be a cause, but in many cases it is difficult to find and impossible to prove. The report of the following case well illustrates these points:

History.—The patient, a man, aged 25, had been under observation for three years with several routine physical examinations. Nothing abnormal had been detected in heart or lungs. He was always considered a healthy, active young man.

Present Illness.—On the day previous to the examination the patient took his usual cold shower, and without an unusual muscular or respiratory effort felt something 'give way' or 'grow loose' in his episternal region. This gave him a queer, indescribable sensation as of something having gone wrong. It caused him to draw a deep breath, and full inspiration was attended by a short, dry, expiratory cough. He went to bed directly, but had to lie perfectly quiet, any change in position being uncomfortable. If he attempted to rise it caught him in his back like a lumbago. He did not consider himself seriously ill, and

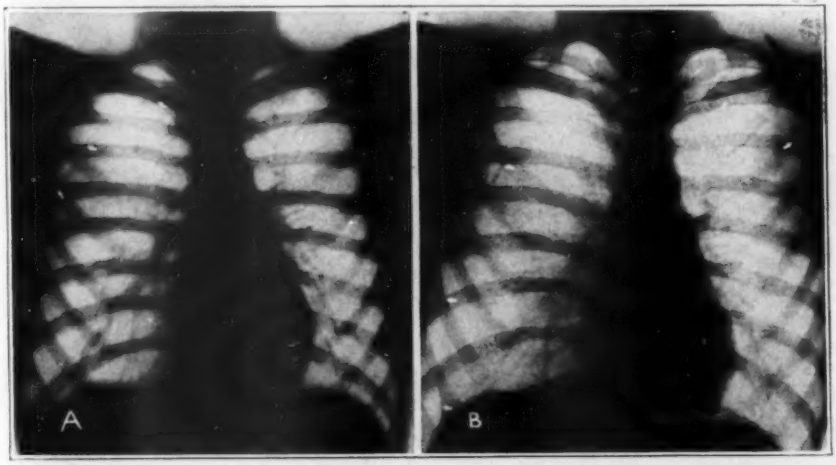

Fig. 1.—*A*, spontaneous pneumothorax of right side—one week later left side also was involved (*B*); complete absence of any evidence of pulmonary tuberculosis in either lung; *B*, spontaneous bilateral pneumothorax which started on right side (*A*); the patient, a man, aged 20, made a complete recovery.

did not feel sick; yet he believed that something had gone wrong inside of him. There was no dyspnea, nausea, chill, fever or sweat and the patient was comfortable when quiet.

Roentgenograms revealed the left chest full of air, the lung being displaced upward and inward, and the heart displaced slightly to the right.

Subsequent History.—One week later, temperature, pulse and respiration remained normal. The patient had daily improved. Pain on sitting up had become less noticeable. Cough on full inspiration was less marked. Physical examination showed continuation of air in the left chest, though amphoric sounds in the upper chest had become fainter and fainter. A few subcrepitant râles had been heard from time to time in the fourth and fifth intercostal spaces just outside the nipple line. These entirely cleared. There was still no appreciable expansion of the left chest, and cardiac dulness remained to the right.

Two weeks later, temperature, pulse and respiration had remained normal throughout the week. The left chest had regained an expansion of one-half inch. Breath sounds had gradually returned to the left upper chest anteriorly and posteriorly but were still faint with a bronchovesicular character below. Cardiac dulness was now elicited 3 inches to the left of the midsternal line in the fifth intercostal space, and heart sounds were now audible to the left of the sternum instead of on the right, as previously.

Roentgen-ray and physical signs showed a normal chest except for a very small amount of air in the left costophrenic chink.

Four weeks later the lungs were absolutely clear, and the heart was normally situated. The patient was feeling fine. There was no dyspnea or cough.

Six months later the patient was normal.

Against tuberculosis are the following: No history of tuberculosis in the family, no previous history of tuberculosis in the patient, no subsequent history

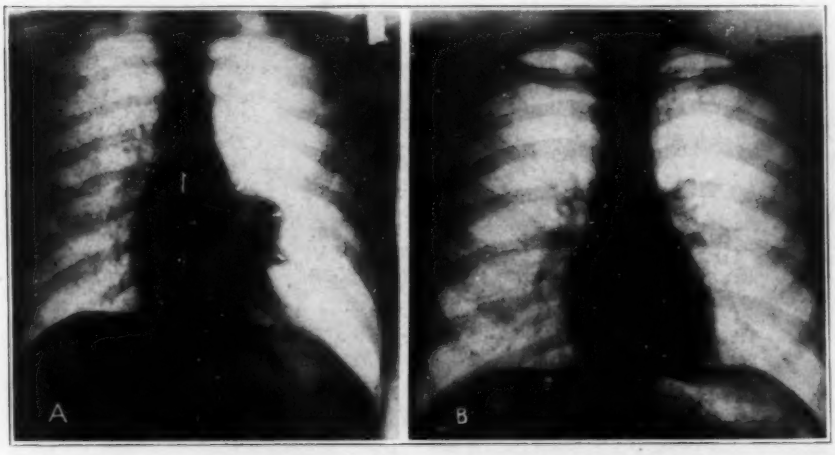

Fig. 2.—*A*, spontaneous pneumothorax of left side; complete collapse of lung; *B*, left lung expanded in a few weeks; the patient, a male medical student, aged 21, was free from pulmonary tuberculosis three years later.

of tuberculosis, no sign in the roentgenogram, and the acute condition of the case. On taking his cold shower the patient may have suddenly taken a deep breath, thus lowering the pressure within the pleural space, rupturing a small point of the lung surface. This may also have been brought about by sudden coughing or sneezing."

Unilateral pneumothorax may persist for years. Bittorf [5] reports a case lasting twenty-five years. Whitney [6] reports one of seven years' duration. I have encountered one case (Fig. 3, A and B) which was observed by roentgen-ray examination over a period of seven years and probably is still present at the end of eight years.

5. Bittorf: München. med. Wchnschr. **55**:2274, 1908.

6. Whitney: Philadelphia Med. & Surg. **115**:397 (Jan.) 1886.

Double pneumothorax in phthisis has been encountered. Fishberg records two cases.[7]

The following is a case of bilateral spontaneous nontuberculous pneumothorax (Fig. 1, A and B).

CASE 1.—A man, aged 20, a bank clerk, was referred by Dr. Clinton L. Bagg, Feb. 7, 1923. While vigorously using an adding machine in conjunction with his occupation, he suddenly felt some pain in the right side. This continued and led to roentgen-ray examination which revealed the typical findings of pneumothorax involving the right side of the chest, with partial collapse of the right lung and slight displacement of the heart toward the opposite side (Fig. 1 A). There was no evidence of tuberculosis of either lung. There were a few calcified glands at the hilum, especially on the left side, the appearance being that observed in nine out of ten roentgen-ray examinations of the chest in persons in good health.

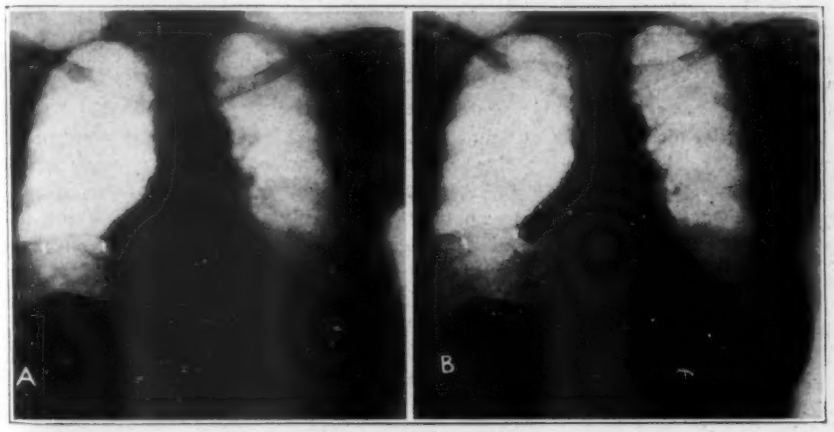

Fig. 3.—*A*, spontaneous localized pneumothorax involving upper two-thirds of right side of chest; the patient, a woman, aged 71, showed the same condition six years before and the condition was unchanged at the end of seven years; *B*, persistent spontaneous pneumothorax; no change observed on roentgen-ray examination over a period of seven years.

The patient was advised to stay at home and keep as quiet as possible and directed to return for roentgen-ray examination in one week.

February 14, the patient returned as directed, suffering apparently from no increase in distress, but the roentgen-ray examination revealed a most remarkable appearance. Not only was there an increase in the collapse of the right lung, but the left lung had collapsed to a degree similar to that of the right lung, one week before. Evidently air had passed from the right pleural cavity into the left pleural cavity in some way, apparently through the upper portion of the mediastinum. The double pneumothorax had the effect of pushing the heart back into its normal position from which it had previously been displaced by the pneumothorax on the right side (Fig. 1, B).

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7. Fishberg: Pulmonary Tuberculosis, Philadelphia, Lea and Febiger, 1922: personal communication to author, May 2, 1925.

The patient returned to his home and as far as could be ascertained, completely recovered his health, but did not return for further roentgen-ray examination.

More than ten cases of unilateral spontaneous pneumothorax have been observed by me. In not a single case has there been any evidence of tuberculosis. Seven of the patients made prompt complete recoveries. Two of the patients showed persistent pneumothorax. The lesion occurred with equal frequency on the right or the left side, but all the cases except one occurred in males. A typical history of one of the cases is as follows:

CASE 2.—S. H. A., a man, aged 23, a medical student (Fig. 2, A and B) stated that he was late, as usual, for class one Saturday morning in November, 1922, and ran up six flights of stairs to the anatomic laboratory. He arrived at about 9:05 and about 9:30 had a sharp, sudden pain in the left scapular region. He had been having a winter cold for two or three weeks and with this pain felt as if there might be fluid in the left side of the chest. He went to the clinic at the Medical College where he is a student and was examined by several physicians. One said he was in the early stages of pneumonia and the others said he had dextrocardia, pleural adhesions and pericardial adhesions. He was sent to the roentgen-ray laboratory for a chest examination and a diagnosis of spontaneous pneumothorax was made (Fig. 2, A). He then felt so bad that he went home to bed. The next day the patient was having difficulty in breathing and was cyanosed. The left side of the chest was immobilized with adhesive and he felt better. He had no difficulty with his heart action.

After the pneumothorax was recognized he was examined by several other physicians, one of whom advised him to give up his entire medical career and go to a climate suitable for tuberculous patients, stating that if he did not have tuberculosis now that he would have it within a year, or words to that effect.

Three years later the patient is in perfect health and is continuing his medical work.

CONCLUSIONS

1. Spontaneous nontuberculous pneumothorax may occur in a person with healthy lungs, and result in complete and permanent recovery.

2. In some persons, air may pass from one pleural cavity to the other, thus producing a bilateral pneumothorax.

3. Bilateral pneumothorax, if of nontuberculous origin, may result in complete and permanent recovery.

4. Unilateral pneumothorax may persist for years.

114 East Fifty-Fourth Street.

DISCUSSION

DR. JAMES ALEXANDER MILLER, New York: I do not agree that these cases are not tuberculosis, nor that they should not be treated as tuberculosis. We are here to discuss spontaneous pneumothorax, and it is difficult to prove that these patients have not tuberculosis.

In a group of ten or more I never could prove that the patients had tuberculosis, but I insisted that they be treated as tuberculous patients, because it

seemed to me that they might have slight lesions which might well cause a rupture of the pleura. We ought to keep the patients under observation, give them rest and see whether tuberculosis develops. Even when I was not able to prove definitely that the patients had tuberculosis, I considered that the cases should be followed for a number of years.

DR. WILLY MEYER, New York: The greatest percentage of spontaneous pneumothorax, perhaps 100 per cent., is certainly due to tuberculosis. One who has witnessed existing conditions in the subway trains of New York City can understand how perforation of an inactive tuberculous focus near the visceral pleura followed by a complete spontaneous pneumothorax can occur in the thickly crowded cars by direct compression of the chest.

DR. GERALD B. WEBB, Colorado Springs, Colo.: Some ten or twelve years ago Dr. Louis Hamman of Baltimore reported a series of cases of spontaneous pneumothorax. At about the same time I saw a case of unilateral spontaneous pneumothorax in a Japanese youth who had run to catch a trolley car. We were unable to make a definite diagnosis of tuberculosis, but as the pathologists have determined that tubercules are early deposited just beneath the pleura, we must agree with Dr. J. A. Miller that it is correct to attribute these cases of spontaneous pneumothorax to pulmonary tuberculosis.

In a similar manner we have learned to consider all hemoptysis as due to pulmonary tuberculosis until otherwise proved.

I have found an occasional case of spontaneous collapse of the lung in families in which one member had had definite tuberculosis. Should complete spontaneous pneumothorax suddenly develop in a patient with well established pulmonary tuberculosis, and the patient be suffering from excessive pressure, we insert a cannula and allow it to remain in the chest wall for several days. This procedure relieves the distress and may enable the patient to recover.

DR. WILLIS S. LEMON, Rochester, Minn.: A number of these cases presented are post-traumatic and are not truly spontaneous in type. Of the latter, I should like to add a word to what Dr. Webb has said. Our experience should lead us, at the beginning, to assume that these patients have tuberculosis and should be so treated. We have very definite reason for believing tuberculous nodules can appear on the surface of the lung.

In the roentgenograms in a number of the cases reported there were calcareous nodules at the hilum of the lung. That would be in keeping with the effects of the primary type of tuberculosis described by Gohn and Opie, which itself might not be recognized in the lung, but will produce lesions in the peribronchial lymph nodes. The resulting inflammation would be one of the reasons why the mediastinum is not materially dislocated.

Dr. Charles C. Macklin shows that the hilum moves and affects the ventilation of the apexes. If this is involved with the inflammatory process, there would be less likelihood of movement. Hodenphyl showed that tubercles might be found on the pleura without recognizable disease within the lung, and I think it is well recognized that the primary type of tuberculosis is subpleural in location. So I feel that there is plenty of reason why such conditions should be treated as tuberculosis, the patients kept under observation for a long period of time and not considered nontuberculous until time has proved the opposite.

DR. LEON T. LEWALD, New York: I am much interested in the different points of view in regard to the question of tuberculosis in these cases, and am not ready to admit that tuberculosis is an important factor in these cases. There was a case reported by Graham in which a pneumothorax had developed with

an apparently healthy lung. Certain cases do *not* have any tuberculous lesion to contend with, and I have held that it is not wise or necessary to consider every case of spontaneous pneumothorax as potentially tuberculosis.

A certain army surgeon was told that he would have to go to a tuberculosis sanatorium as a patient. He said he would resign from the army rather than go to a tuberculosis sanatorium. He was not compelled to resign. He never did develop tuberculosis. One has to bear in mind that there are cases that closely simulate tuberculosis from the clinical standpoint, but from the roentgenologic standpoint are definitely excluded.

In regard to Dr. Willy Myer's remark relative to overcrowding in the subway as a possible competent cause for production of spontaneous pneumothorax, I would like to record the fact that one of my cases did occur while the patient was riding in the subway.

THIRTEEN FOREIGN BODIES REMOVED FROM ESOPHAGUS AT ONE SITTING

SIDNEY YANKAUER, M.D.
NEW YORK

A woman suffering from melancholia associated with menopause swallowed thirteen foreign bodies with the intention of committing suicide.

She was brought to an institution in New York because she was losing weight in the institution in which she had been previously kept; she would not take nourishment. When she arrived in New York we found that she could not take nourishment. A roentgenogram showed foreign bodies in the esophagus and an equally large collection in the stomach and in the intestines. The patient was too restless to be examined by esophagoscope without a general anesthetic.

All these foreign bodies, with the exception of a large piece of crockery, were located above the point where the arch of the aorta crosses the esophagus. The first one to be reached was the large screw; then the rest were removed. The difficulty in the case was the necessity of frequently removing and reintroducing the esophagoscope because the objects would not come through the tube. A hairpin was taken out. Fortunately, it lay with the point down so that it could easily be removed. A second hairpin was taken out. A nail and a needle were lying close together, crosswise. Then two hairpins appeared which came out together. The next object was a piece of pottery. This was too large to go through the esophagoscope, so it had to be withdrawn with the tube. A piece of glass was taken out, and we had to go in another time for a second piece; then we introduced the esophagoscope for a safety pin and other pieces of glass and crockery. After this, it was not possible to see a large piece of crockery that was low down in the esophagus, and I had to introduce a longer esophagoscope and find this large piece of crockery.

These manipulations consumed half an hour. Then I proceeded to the removal of the large piece of crockery. That is where I was up against it, because it lay with its broad side upward and the edges oblique and no forceps would hold it. It was tightly wedged in. One of the first things that happened was that one of the most powerful forceps snapped at the joint and I had to remove the joint before I could proceed further.

Finally, by slowly and carefully manipulating the foreign body, doing what we call "walking it out," that is, raising one side first, then

the other, I succeeded after an hour and a half of effort in getting this large foreign body out. Altogether, the operation took two hours. However, the next day the patient called for food and was able to take it without any difficulty and had no reaction whatever, even though the esophagoscope had been introduced seven times. The patient has since passed most of the foreign bodies in the abdominal cavity and is slowly making recovery.

DISCUSSION

Dr. John D. Kernan, New York: I think Dr. Yankauer has conclusively proved that as far as foreign bodies in the esophagus are concerned the thoracic surgeon is completely out of business. After this demonstration, I think anything in the way of foreign body in the esophagus can be tackled and successfully removed. I am not sure that every esophagist would have gone on to the thirteenth. I am sure I would not. I might have tackled the twelfth, but the thirteenth would have completely stuck me.

PROCEEDINGS

Sunday, May 3—Evening

The council met in executive session at 8:30 p. m.

Monday, May 4—Morning

The meeting was called to order at 9:45 by the president, Dr. Nathan W. Green, New York, in the U. S. National Museum, Washington, D. C.

The appointment of committees and delegates to the Congress of American Physicians and Surgeons was announced.

Dr. Nathan W. Green, New York, read the president's address, "What May We Expect Today from Thoracic Surgery?"

Dr. John L. Yates, Milwaukee, read a paper on "Vital Capacity in Intrathoracic Surgery." Discussion was opened by Dr. James Alexander Miller, New York, who was followed by Drs. Francis W. Peabody, Boston, by invitation; Edward D. Churchill, Boston, by invitation; Evarts A. Graham, St. Louis; Howard Lilienthal, New York, and John L. Yates, Milwaukee.

Dr. Willis S. Lemon, Rochester, Minn., read a paper on "An Experimental Study of Aspiration." Discussion was opened by Dr. Willy Meyer, New York, who was followed by Drs. Evarts A. Graham, St. Louis; Carl A. Hedblom, Madison; David A. Stewart, Ninette, Manitoba; Charles Gordon Heyd, New York; Frederick T. Lord, Boston; Edward W. Peterson, New York, and Willis S. Lemon, Rochester, Minn.

Dr. Leon T. LeWald, New York, read a paper on "Spontaneous Unilateral and Bilateral Pneumothorax." Discussion was opened by Dr. James Alexander Miller, New York, who was followed by Drs. Willy Meyer, New York; Gerald B. Webb, Colorado Springs, Colo.; Willis S. Lemon, Rochester, Minn., and Leon T. LeWald, New York.

Monday, May 4—Afternoon

Dr. Willy Meyer, New York, read a paper on "Postoperative Gangrene of Lung with Encysted Empyema; Operation; Recovery."

Dr. Carl Eggers, New York, read a paper on "Lung Abscess Complicated and Hidden by Empyema."

These two papers were discussed by Drs. Adrian V. S. Lambert, New York; Frederick T. Lord, Boston; Evarts A. Graham, St. Louis; Howard Lilienthal, New York; Carl A. Hedblom, Madison, Wis.; Sidney Yankauer, New York; Franz Torek, New York; John D. Kernan, New York; George J. Heuer, Cincinnati; Willis S. Lemon, Rochester, Minn.; Nathan W. Green, New York, and Willy Meyer, New York.

Dr. Franz Torek, New York, read a paper on "Actinomycosis of Lung, with Report of a Case." Dr. Robert T. Miller, Jr., Baltimore, read a paper on "Congenital Cystic Lung." Dr. Harold Brunn, San Francisco, read a paper on "Primary Carcinoma of the Lung, with Reports of Two Operative Cases." These three papers were discussed by Drs. Frederick T. Lord, Boston; Howard Lilienthal, New York; Evarts A. Graham, St. Louis; Alexis Carrel, New York; Carl A. Hedblom, Madison, Wis., and Robert T. Miller, Jr., Baltimore.

Dr. Sidney Yankauer, New York, read a paper on "Thirteen Foreign Bodies Removed from the Esophagus at One Sitting." Discussion was opened by Dr. John D. Kernan, New York, who was followed by Dr. Franz Torek, New York.

Tuesday, May 5—Morning

The meeting was called to order at 9 a. m.

Dr. Elliott Carr Cutler, Cleveland, by invitation, read a paper on "The Surgical Aspect of Mitral Stenosis." Discussion was opened by Dr. Duff S. Allen, St. Louis, who was followed by Drs. Howard Lilienthal, New York, and Elliott Carr Cutler, Cleveland.

Dr. David A. Stewart, Ninette, Manitoba, read a paper on "The Medico-surgical Borderland in Thoracic Tuberculosis." Dr. S. Adolphus Knopf, New York, by invitation, read a paper on "The Medical Care of Tuberculous Thoracoplastic Cases." Dr. Willy Meyer, New York, introduced for general discussion the topic "Is it Justifiable to Continue Refusing Consumptives, in Need of Operative Help, Temporary Admission to the Surgical Wards of Our Hospitals?" Discussion on the papers by Drs. Stewart and Knopf, and on the topic introduced by Dr. Willy Meyer, was opened by Dr. Edward W. Archibald, Montreal, who was followed by Drs. S. Adolphus Knopf, New York, Carl A. Hedblom, Madison, Wis., Wyman Whittemore, Boston, Philemon E. Truesdale, Fall River, Mass., and Willy Meyer, New York.

Tuesday, May 5—Afternoon

The council met in executive session at 2 p. m. The association as a whole met in executive session for the election of officers, election of new members, and other business at 2:30 p. m.

The scientific program was continued at 3 p. m., the discussion commenced in the morning on the papers by Drs. David A. Stewart, S. Adolphus Knopf and Willy Meyer being concluded.

The following papers were read as a symposium on "The Present Status of Operative Surgery and of Radiation in the Treatment of Cancer of the Esophagus and Cardia."

Dr. William S. Stone, New York, by invitation: "Radium Therapy in Carcinoma of the Esophagus."

Dr. Franz Torek, New York: "Surgical Treatment of Carcinoma of the Esophagus."

Dr. Chevalier Jackson, Philadelphia: "Why Does Not the Thoracic Surgeon Cure Cancer of the Esophagus?"

Dr. Herman Fischer, New York: "A New Method of Esophageal Implantation into the Stomach After Intrathoracic Resection of the Esophagus for Carcinoma."

Dr. Sidney Yankauer, New York: "A New Method of Applying Radium to Carcinoma of the Esophagus and Cardia."

These five papers were discussed by Drs. James T. Case, Battle Creek (by invitation); Carl A. Hedblom, Madison, Wis.; Howard Lilienthal, New York; Willy Meyer, New York; Charles Gordon Heyd, New York; Leon T. LeWald, New York; Franz Torek, New York; Hermann Fischer, New York, and Sidney Yankauer, New York.

Wednesday, May—6 Morning

The meeting was called to order at 9:30 a. m. at Walter Reed General Hospital.

Dr. William L. Keller, Washington, conducted a follow-up clinic on cases of chronic empyema that had been operated on by radical thoracoplastic procedures three years previously, and had been presented to the association at that time as recent operative cases.

Wednesday, May 6—Afternoon

The association met with the other component associations of the Congress of American Physicians and Surgeons in a general meeting of that body.

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